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Effectiveness of Selected Media for Removal of Hydrogen Sulfide

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EFFECTIVENESS OF SELECTED MEDIA FOR REMOVAL OF HYDROGEN SULFIDE

by

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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INTRODUCTION

General

The anaerobic lagoon has proven to be a successful and economical method of treating certain industrial wastewaters. However, anaerobic decomposition results in the production of odorous substances such as hydrogen sulfide, mercaptans, indoles, skatoles, and volatile acids. When certain loading or atmospheric conditions exist these odors may cause nuisance conditions. In addition, if the wastewater contains sulfate concentrations in excess of 400 mg/1, large quantities of hydrogen sulfide will be produced resulting in noxious odors (1, 2). These odors can migrate several miles, producing nuisance conditions over a large area (3, 4).

Although the production of odors in anaerobic lagoons is an inherent problem associated with this process, very little research has been done to alleviate this nuisance. As a result, state regulatory officials have not been enthusiastic in the promotion of anaerobic lagoons, and in many instances more expensive alternate treatment methods have been utilized.

An economical method of removing odors would not only stimulate the use of relatively inexpensive anaerobic systems in place of more expensive conventional systems, but would also improve the aesthetic suitability of many

existing lagoons. A suitable odor control method would also provide a means of compliance for industrial establishments using anaerobic lagoon systems that are meeting effluent standards, but not complying with air pollution regulations. The studies described herein represent a preliminary effort toward developing an effective and economic method for controlling odors from anaerobic lagoons.

Objectives

The objectives of this investigation were:

1. to determine experimentally the effectiveness of various materials in reducing odors resulting from anaerobic treatment of wastewater.
2. to provide a recommendation concerning the thickness of the most effective materials for use as a cover to reduce odors from anaerobic lagoons.

Scope of the Research

In this project, the removal of hydrogen sulfide from digester gas by various materials was evaluated. Hydrogen sulfide was chosen for study because it is the most characteristic malodorous gas produced by anaerobic decomposition of high-sulfate wastewater and it can be determined quantitatively with relative ease. Gas from sewage treatment plant digesters rather than laboratory units was utilized to insure a quantity sufficient for the experiments. Also, gas from this source would closely resemble

the gas produced in anaerobic lagoons. The investigation was limited to evaluating the effectiveness of each material in removing hydrogen sulfide, and no tests were conducted to determine the mechanisms by which removal was accomplished.

LITERATURE REVIEW

The literature review that follows was conducted to enumerate the methods employed to reduce odors from anaerobic lagoons, and to evaluate the potential of other odor control methods that might possibly be adapted to anaerobic lagoon odor control. Previous research on biological odor control systems is also included to aid in the interpretation of the results.

Anaerobic Lagoon Odor Control

Covers

Scum layers that often form on anaerobic lagoons treating meat packing wastes, have been reported to be effective in eliminating or reducing odors normally produced during anaerobic decomposition (2, 5, 6, 7, 8, 9, 10). These covers result from the build-up of grease and/or paunch manure and may range in depth from several inches to several feet. Many investigators have noted that odors were a problem prior to the development of a "scum layer", but were reduced below nuisance levels after covers formed (6, 7, 8, 9). Hydrogen sulfide was among the causes of these odors as evidenced by severe corrosion of concrete inlet and outlet structures.

In 1957, Sollo and Sanders patented a method for controlling the thickness of the scum layer by inhibiting the

growth of Psychoda larvae (11). An increase in thickness was effected by coating the scum surface with larvicide or applying used crankcase oil at a rate of 1 gal/20 ft^2 (11).

Artificial covers, which have been constructed on several anaerobic lagoons to help retard heat loss, have also reduced odors (6, 12, 13). Etzel described a system where styrofoam blocks three inches thick, 16 inches wide, and nine feet long were floated on an anaerobic lagoon treating corn-milling wastes (6). The cover aided in odor control, but it was also necessary to add 300 gallons of odor masking chemicals each summer. Dornbush, et al., (13) reported that a cover of styrofoam overlain with straw reduced odors from an anaerobic lagoon treating potato wastes. Styrofoam blocks were also used to cover an anaerobic lagoon treating potato wastes in Idaho to retard heat loss and control odors (12).

Covers on anaerobic lagoons not only maintain heat and aid in odor control, but also reduce the airwater interface eliminating aeration or algal growth. Thus, strict anaerobic conditions are maintained, which is the most suitable environment for acidogenic bacteria as well as the delicate "methane formers".

Biological

There have been instances reported in which the reduction in odor from anaerobic lagoons was attributed to the presence of photosynthetic sulfur bacteria of the family Thiorhodaceae (14). However, attempts to reduce odors by innoculating lagoons with various pure cultures have not been successful (15). Additionally, anaerobic lagoons in northern climates should be covered to retard heat loss and this would impair the growth of photosynthetic organisms by eliminating sunlight.

Odor Counteraction and Masking Agents

Odor masking and counteraction agents have been used to retard odors from anaerobic lagoons. They have also received considerable use in other wastewater treatment and collector systems with varying success (16, 17, 18, 19, 20).

Counteraction is the addition of one odorous substance to another resulting in the formation of a mixture with little or no odor (19). The odors are antagonistic so upon mixing, the intensity of each is diminished (18). Masking refers to the addition of a pleasant odor in significant concentration to render the unpleasant odor unrecognizable. In actual practice, these differences are negligible because complete counteraction is nearly impossible. For total counteraction to occur, the control

agent must be completely mixed with the existing odors and allowed to combine with them on a selective basis (15). The odors produced during anaerobic decomposition result from mixture of odorous substances and so far, the complexity of the mixture has been an insurmountable obstacle to those attempting to develop a suitable counteractant.

Odor masking and counteraction agents are normally vaporized and sprayed over the source of noxious odors, but they may also be injected into wastewater flows. Strict control of the application rate is required because overfeeding causes the odor of the control agent to prevail and underfeeding does not eliminate the noxious odors (16). Selection of the proper application rate is largely by trial and error because of the changing odors and weather conditions around wastewater treatment plants (19).

The effectiveness of odor-control chemicals has varied from situations where the resulting odors were pleasant to occurrences where the combination of hydrogen sulfide and an odor-masking agent resulted in the formation of an odor more objectionable than the original noxious odor (15). Furthermore, odors that are pleasant to some are considered objectionable to others. Also, a series of masking agents may have to be used in rotation to avoid olfactory fatigue, which allows the human nose

to detect the noxious odor. Although utilization of odor-control chemicals is costly and results are varied, they continue to receive considerable use because of the lack of more suitable control techniques.

Miscellaneous Odor Control Techniques

Many methods have been developed to eliminate sulfide odors resulting from wastewater treatment and collection, and industrial operations. The methods which have been used rely on physical and chemical mechanisms such as: 1) adsorption, 2) chemical oxidation, 3) chemical precipitation, 4) combustion and 5) wet and dry scrubbing. Recently, biological oxidation in the form of a soil filter has also been studied and applied as a method of eliminating odors produced in sewers and wet wells (21, 22, 23).

Adsorption

Activated carbon is the adsorbent used most often to remove odors (19, 24, 25, 26). It is the most practical adsorbent because its performance is not affected by moisture (25). Systems employing activated carbon are extremely effective because most odorous vapors have a high molecular weight and are adsorbed readily (27). However, their use is limited in wastewater applications because large units and frequent regeneration or replacement of the carbon is necessary as a result of the large

quantities of odorous gases produced. In addition, an explosion hazard may develop from excessive heat generated when activated carbon is used to remove hydrogen sulfide (28).

Chemical Oxidation

Oxidizing agents, such as chlorine, ozone, chromates, and halogenated hydrocarbons, have been used successfully to control odors in sewers and industrial processes (19, 25). However, these materials are also disinfectants and would not be applicable for use in an anaerobic lagoon.

Chemical Precipitation

Metallic ions such as zinc, copper, and iron have been used to control sulfide odors in sewers (19). The metal ions combine with sulfide to form insoluble precipitates, thereby reducing odors. Other metallic ions are toxic and have been used to inhibit biological growth thereby reducing odors.

Ferric chloride has proven effective in controlling odors in digester supernatants and sludges by precipitating sulfides (19). However, continued use of ferric chloride in an anaerobic lagoon for odor control would be prohibitive from a cost standpoint.

Combustion

Combustion or incineration has received considerable

use in controlling odors (19, 24, 25, 26, 29, 30, 31, 32, 33). During combustion, the elements in organic matter combine with oxygen to produce highly oxidized products with little or no odor. Temperatures within a range of 1200 to 1500°F are normally required for effective odor elimination (24, 26, 29, 30). However, to insure complete deodorization at all times, a temperature of 1500°F should be maintained (19, 30).

Catalytic oxidation has also been used to oxidize odorous gases (19, 25, 33). The catalyst speeds oxidation and allows odor destruction at lower temperatures usually in the range of 500°-800°F (19, 31). These methods would have limited application for the control of odors from anaerobic lagoons because collection of the gas and a special furnace would be required.

Scrubbing

Scrubbing has been used for years to remove hydrogen sulfide from gas streams. In wastewater treatment, scrubbing has been used primarily to remove hydrogen sulfide from digester gas to prevent excessive corrosion of boilers or gas engines rather than to eliminate odors. Industrial applications have been restricted primarily to the purification of natural or coal gas, but hydrogen sulfide has also been removed to reduce odors generated in manufacturing processes such as pulping.

The conventional method of dry scrubbing involves oxidation of the hydrogen sulfide with iron oxide (34, 35). The gas stream is exposed to coarse wood shavings coated with iron oxide and supported in baskets. The chemistry is complicated and involves the formation of a variety of polysulfides, thiosulfates, and sulfur (34). One cubic foot of these iron-coated wood shavings will remove 6.7 lbs of hydrogen sulfide (34). When the shavings are spent, they are regenerated by exposure to air. For gases containing concentrations of hydrogen sulfide greater than about nine mg/l, excessive regeneration makes the system impractical and costly to maintain (34). Most of these "dry box" systems have been phased out in favor of more efficient units.

A mixture of wood shavings, calcium carbonate, iron oxide and calcium sulfate have also been patented for use in dry scrubbing of hydrogen sulfide (36). In another case, cement was added and columns 61 cm high and 0.8-1.2 cm in diameter were formed for use in hydrogen sulfide removal (37). Red mud, which is a waste product from the manufacture of aluminum from bauxite, mixed with sawdust and lime has also been used successfully to remove hydrogen sulfide (38). The U.S. Bureau of Mines found that ferric oxide plus fly ash, ferric oxide plus pumice, and red mud were all effective in removing hydrogen sulfide and were completely regenerable in air (39). Pauli (40)

reported that a system consisting of baskets full of redwood shavings and iron filings was effective in removing hydrogen sulfide from digester gas. It should be noted that all materials used in dry scrubbing must be regenerated.

Packed towers, venturi-type injectors, fine-bubble diffusers and liquid sprayers are the devices commonly used in wet scrubbing. Water may be used as the absorbent, but hydrogen sulfide is seldom present in the gas at a high enough partial pressure to make water absorbtion practical. The Miami sewage treatment plant, however, does utilize a three-stage water absorption system to scrub hydrogen sulfide from digester gas (34).

Ethanolamines, aqueous ammonia, and alkaline salt solutions are commonly used as absorbents (27). Alkaline solutions are not practical when a significant amount of carbon dioxide is present because the carbon dioxide is absorbed before the hydrogen sulfide. Rains, et al., (41) reported that odors from a sludge thickener were reduced below detectable limits by scrubbing with a water solution containing 1.5 mg/l residual chlorine.

Some of the processes for removing hydrogen sulfide available commercially include the Stretford, Beavon, and Cleanair systems (35). These processes are used primarily in large-scale installations and may not be applicable

for anaerobic lagoon odor control.

Biological Oxidation

There are a large number of microorganisms capable of oxidizing reduced sulfur forms. These organisms are primarily autotrophs or facultative autotrophs, but some rely on photosynthesis for their energy source.

Beggiatoa, Thiothrix, and Thioplaca are filamentous organisms capable of oxidizing reduced sulfur forms (42). Beggiatoa are aerobic to microaerophilic organisms that exist in marine or fresh water environments in the presence of hydrogen sulfide (43). Thioplaca are aerobes that are found in upper layers of brackish or fresh-water mud containing calcium carbonate and hydrogen sulfide (43). Thiothrix are strict aerobes that exist in marine environments with high concentrations of hydrogen sulfide. They are especially adapted to flowing waters and are often found in sewage treatment plants (43).

Organisms in the families Chromotiaceae (formerly Thiorhodaceae) and Chlorobacteriaceae are photosynthetic anaerobes capable of converting hydrogen sulfide to elemental sulfur (43). They do not require organic growth factors, but must have ultraviolet light for growth (42). These organisms exist in moist and muddy soils, ditches, ponds, sulfur springs, rivers, salt lakes, and estuaries (43).

Organisms of the genus Thiobacillus are strict autotrophs which utilize sulfur for energy (42). They may cause severe damage to concrete structures by oxidizing hydrogen sulfide to sulfuric acid. The organisms principally involved are T. thiooxidans, T. thiosparus and T. concretivorus (44). T. thiooxidans may grow at a pH as low as one, but optimum growth occurs at pH 3 to 6 (42).

The thiobacilli are primarily aerobic, but one facultative anaerobe, T. denitrificans, has been identified that is capable of oxidizing reduced sulfur forms. It utilizes nitrates rather than oxygen as a terminal electron acceptor, but requires ammonia as a nitrogen source (42).

In summary, the organisms which oxidize reduced sulfur are primarily aerobic. Additionally, the obligate anaerobic organisms that utilize reduced sulfur forms are photosynthetic. There are very few, if any, strict anaerobic, non-photosynthetic organisms that can utilize hydrogen sulfide.

Soil Filter

Pomeroy was among the first to use soil filters for removing odorous substances (23). He reported that malodorous gases were removed as a result of biological oxidation in the soil (23). In the laboratory, he passed an air stream containing valeric acid, skatole, and phenol

through a column of moist clay 24 inches high and two inches in diameter. Subsequent field tests were conducted at a sewage pumping station in Long Beach, California. Sewage gas was passed through two identical soil diffusion trenches at 730 cubic feet per minute (cfm). No odors were detected in the emerging gas. Pomeroy received a patent for the system in 1957 (23).

Mayo conducted field-scale tests of soil filters using odors produced in wet wells on Mercer Island, Washington (23). In this study, sewage gas from the wet wells was forced through a soil filter by the rising and falling water level in the wells. The filter consisted of four-inch plastic diffuser lines covered by two inches of gravel and 18 inches of soil. The Mercer Island system was operated sucessfully for over three years.

Carlson and Leiser (22) conducted extensive studies on the use of soil filters for the removal of hydrogen sulfide. They passed a mixture of hydrogen sulfide and air through several types of soil contained in columns 6 inches in diameter and four feet high, and plywood chambers 2 feet wide by 4 feet long by 4 feet high (22). It was found that moist loam soils had excellent possibilities in the efficient and inexpensive removal of hydrogen sulfide from air streams (22). The results indicated that odor reduction was affected by microorganisms in the

soil rather than by ion-exchange, chemical oxidation, or soil and water adsorption (22). Over a three-month test period, hydrogen sulfide gas concentrations of 15 mg/l at a flow rate of 0.35 cfm per square foot of soil surface were reduced to imperceptible levels by 32 inches of soil. For a flow rate of 0.34 cfm per square foot of soil and a hydrogen sulfide concentration of 9.5 mg/l, 90 per cent of the hydrogen sulfide was removed in the first 18 inches of soil. Carlson and Leiser noted that environmental conditions should be optimal for growth of microorganisms (i.e. moist, 35°C).

Carlson and Leiser (22) proposed a system for the treatment of odorous gases that consisted of a greenhouse and buffered irrigation system. The odorous gases were blown through a perforated tube that was covered with soil. The system was enclosed in a greenhouse to facilitate year-round plant growth. The role of the vegetation within the system was to maintain the soil in a loose condition, thereby improving aeration and passage of gases through the soil. In addition, the plants helped to reduce sulfate concentrations in the soil and resupply soil organics.

Carlson and Gumerman conducted similar soil-column studies using both hydrogen sulfide and methyl mercaptan. Moist loam soil was found to remove 775 mg/l methyl

mercaptan at a flow rate of 0.85 liter per week per cubic foot of soil. Hydrogen sulfide removals were similar to the previous study (21).

Microbiological mechanisms were again determined to be primarily responsible for the removals, with water and soil adsorption producing negligible effects. Bacteria counts decreased during the first week of study, and then increased for the remaining time. They postulated that hydrogen sulfide and methyl mercaptan were toxic to some microorganisms initially, but those capable of utilizing hydrogen sulfide and methyl mercaptan as a substrate continued to grow. Thiobacilli were identified, but they represented a minority of the bacterial growth on the culture media.

Carlson, et al., (23) in a later publication, provided an extensive description of the odor removal mechanisms of the soil filter (23). Results indicated that Lynden Loam at a pH of 8.0 and a temperature of 45°C was the most effective material in the removal of hydrogen sulfide and methyl mercaptan. The same material was less effective at pH 4.0 and 5.8 which suggests that sulfhydryl ion (HS^-) and not H_2S was the active specie.

Hydrogen sulfide was removed by dry and wet soil columns. In dry, sterile soil, adsorption appeared to be the major removal mechanism, together with surface-catylyzed reactions. In wet soils, removal also depended

on the rate at which hydrogen sulfide solution would dissolve in water. At hydrogen sulfide concentrations above 100 mg/l, it was found that dry soils were more effective because the time required for removal decreased with increasing moisture.

For concentrations of hydrogen sulfide below 100 mg/l biological removal mechanisms were effective. Methyl mercaptan and hydrogen sulfide removals were the same as those previously reported (21, 22). The removals increased with increasing moisture in the range of 5-20 per cent. Methane was not removed either singly or in combination with air, carbon dioxide, or hydrogen sulfide.

They listed the following factors that should be considered in designing soil filters:

1. Detention time
2. Temperature
3. Quantity of hydrogen sulfide
4. Concentration of hydrogen sulfide
5. Gas flow rate

These investigators noted that when properly designed, soil filters operated in a range favorable to biological growth and were capable of continuous operation for long periods of time.

The use of soil filters for removal of animal waste odor was also reported (45). Soil filters were found

effective in removing both hydrogen sulfide and ammonia from head space gas over decomposing poultry manure. During a three-month period, 100 per cent removals were attained for ammonia concentrations up to 200 mg/l and 95 per cent removals were attained for hydrogen sulfide concentrations of 22 to 100 mg/l.

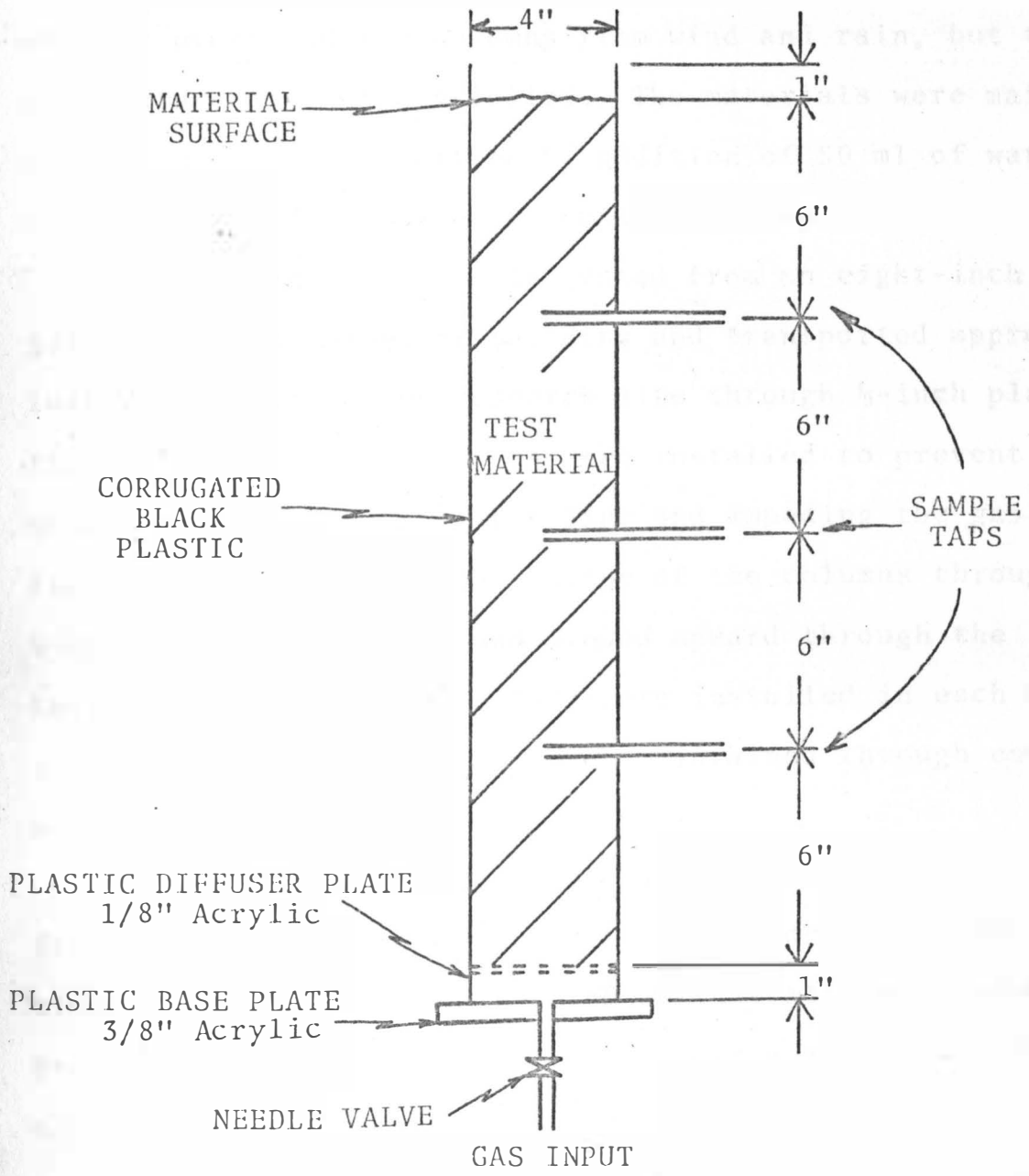
Thus, specific attempts to evaluate the problem of odors from anaerobic lagoons could not be found in the literature. Therefore, the experiments described in the sections that follow would appear to be the first to be reported in which the effectiveness of various materials that could be used to cover an anaerobic lagoon is determined.

METHODOLOGY

Experimental Apparatus

Fourteen different materials or mixtures of materials were evaluated in this study. These materials were placed to a depth of 24 inches, in corrugated, black plastic columns, four inches in diameter and 26 inches high. A typical test column is depicted in Figure 1. The corrugations in the opaque plastic columns prevented gas from flowing up the sides of the columns, thereby alleviating the need for baffles on the column interiors. A dispersion plate made of plastic was installed one inch from the bottom of each column. The dispersion plates supported the test materials and provided a uniform distribution of gas across the column cross-section. Sampling taps, consisting of ¼-inch Tygon tubing, allowed sampling at six-inch intervals throughout the depth of each material. The taps were sealed with clamps except during sampling. The tops of the columns were not covered to simulate field conditions.

The materials were evaluated using twenty-eight columns so that duplicate columns of each material could be analyzed, thereby reducing experimental error. The columns were housed in an insulated, wood-framed shelter located adjacent to the digesters at the municipal sewage treatment plant, Sioux Falls, South Dakota. The field



NOTE: All columns four inch O.D. corrugated black plastic tubing.
Liquid rubber used to seal leaks.
Sampling taps sealed with clamps.

Figure 1. A Typical Test Column

shelter protected the columns from wind and rain, but the temperature was not controlled. The materials were maintained in a moist condition by addition of 50 ml of water from an aerated lagoon each sampling period.

The digester gas was collected from an eight-inch gas main in the digester building and transported approximately 30 feet to the research site through ½-inch plastic tubing. Two water traps were installed to prevent condensate from clogging the line and impeding the gas flow. The gas entered the bottom of the columns through ¼-inch Tygon feed lines and flowed upward through the test materials. Needle valves were installed in each feed line so that equal flow could be maintained through each material.

The gas flow was maintained at 0.025 cfm for the first two weeks of study and 0.0125 cfm for the remaining time. The flow rate was reduced so that it simulated gas production of an anaerobic lagoon. The gas pressure was maintained at approximately 11 inches of water.

The gas flow was measured with a gas meter manufactured by Metric Metal Works, Erie, Pa., and recorded each sampling date. If a large discrepancy in flows was noted, it was changed by adjusting the needle valve in the gas line feeding the column. Some variations in gas flow occurred because of changes in digester pressure and

ambient temperatures, but overall, a relatively constant and equal flow was maintained to all columns. The apparatus is depicted photographically in Figures 2 and 3.

The fourteen materials, or combination of materials that were selected for evaluation are presented in Table 1. These materials were chosen because of their similarity to materials with odor-removal potential mentioned in the literature and/or they were inexpensive and readily available. A more complete description of these materials may be found in Appendix I.

Table 1

Materials Selected for Odor-Removal Evaluation

Chopped paper	Styrofoam
Soil	Straw
Sawdust	60% Corncobs, 40% manure[1]
Ground corncobs	Elm leaves
Alfalfa	60% Sawdust, 40% manure[1]
Peat moss	Wood chips
Cow manure	Scum layer from anaerobic lagoon

[1]By weight

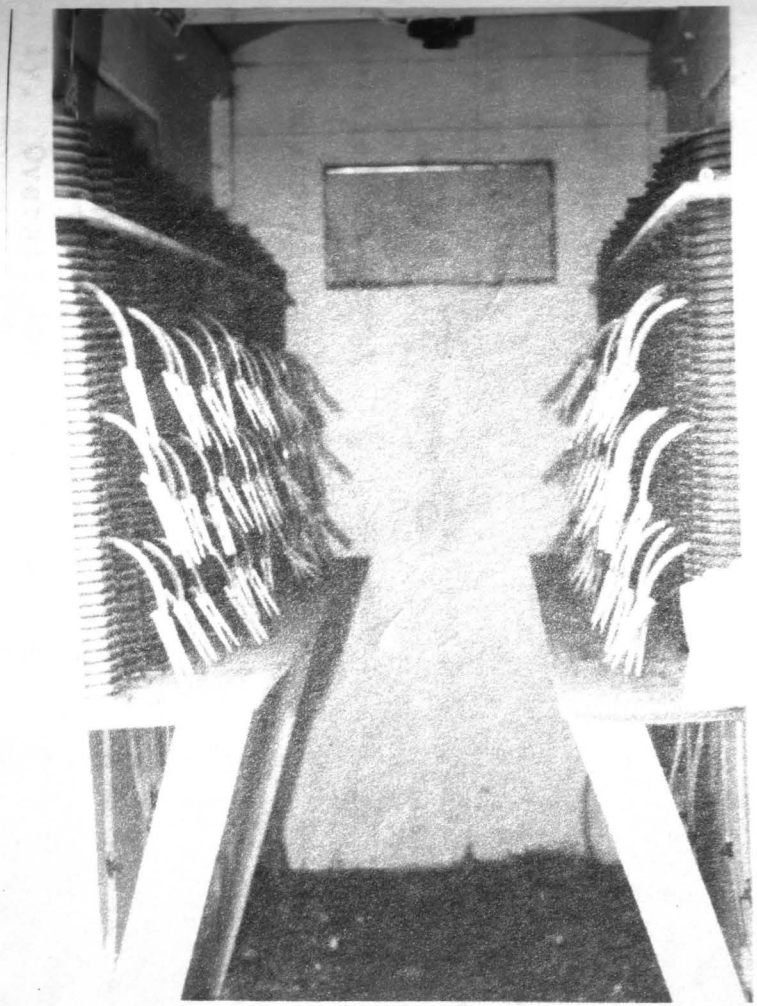


Figure 2. Overall View of Test Columns.

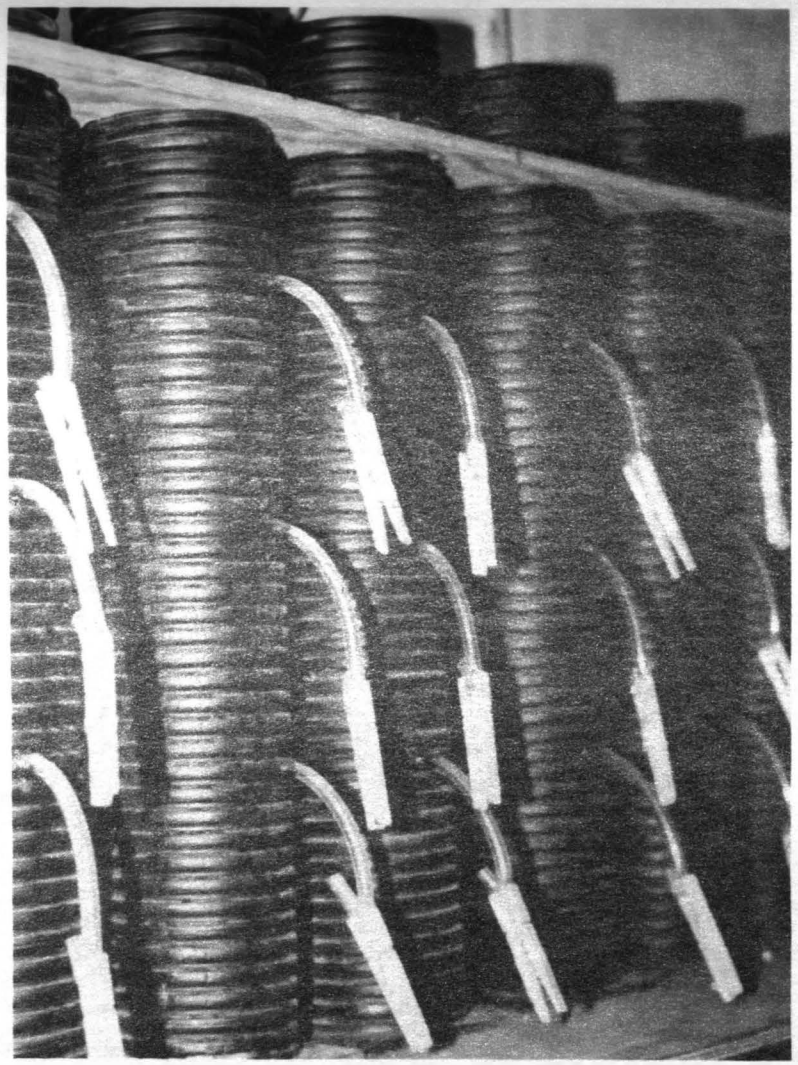


Figure 3. Close-up View of Test Columns.

Sampling Procedures

A preliminary study lasting about 30 days was conducted initially to de-bug the experimental apparatus and develop the operating and analytical techniques required to successfully complete the experiments. Data collection was initiated on September 1, 1974, and completed on November 4, 1974, a period of 65 days.

Samples were collected approximately twice each week for the first 48 days and once each week thereafter. Samples for a given run were collected and analyzed for six, 12, 18 and 24-inch depths from the bottom of each column. The top sample (at 24 inches) was collected by placing a plastic cover over the column. The sample was collected approximately five minutes after covering the column, a period sufficient to allow the clear space between the cover and the material in the column to be purged of air by the digester gas.

Analytical Determination

A Tutweiler apparatus was utilized for the hydrogen sulfide analyses. The apparatus has been reported capable of measuring hydrogen sulfide concentrations as low as 3 grains/100 ft^3 (0.07 mg/l) (46), however, during these investigations, it was found that concentrations below 10 grains/100 ft^3 (0.23 mg/l) could not be measured accurately. Overall accuracy of the instrument was estimated at

± 5 percent. It should be noted that the measurements were not corrected for temperature and pressure because the corrections were less than the accuracy of the unit. Although more accurate methods for determining hydrogen sulfide are available, the expenditures of time and money necessary to achieve the slight increase in accuracy made possible by using more elaborate instrumentation would have been out of proportion to the additional benefits obtained (47).

RESULTS AND DISCUSSION

The data compiled during these investigations are presented in Appendix II. An analyses of variance (ANOVA) was conducted to aid in the interpretation of the data because of the large number of measurements that were recorded, and the numerous changes that occurred. The ANOVA, presented in Appendix III, indicated that all the materials analyzed were significantly different at the 5 per cent level, and that significant changes in hydrogen sulfide removal efficiency occurred with respect to time and depth of material. Therefore, the depth and time interactions were subjected to further analysis.

Hydrogen Sulfide Removal as a Function of Time

The per cent of hydrogen sulfide removed generally increased with time for each material during the period of study, however, the removal efficiencies attained by each material varied considerably. In Table 2, the materials are ranked in order of their effectiveness in removing hydrogen sulfide, and arbitrarily classified as high, intermediate or low.

The materials were ranked and classified according to the removal efficiencies they attained by the end of the study. A low rating indicated the trend in hydrogen sulfide removal efficiency did not exceed 60 per cent

Table 2

Relative Effectiveness of Test Materials in Removing Hydrogen Sulfide

Material	Rating
Soil	High[1]
Manure	High
Manure and Sawdust	Intermediate[2]
Manure and Corncobs	Intermediate
Straw	Intermediate
Scum layer	Intermediate
Wood chips	Low[3]
Sawdust	Low
Elm leaves	Low
Alfalfa	Low
Peat moss	Low
Styrofoam	Low
Corncobs	Low
Paper	Low

[1]Removal efficiency higher than 75 per cent
[2]Removal efficiency between 60 and 75 per cent
[3]Removal efficiency below 60 per cent

during the period of study; an intermediate rating indicated removal efficiencies between 60 and 75 per cent were

attained; and a high rating indicated a removal trend in excess of 75 per cent.

Corncobs and Paper

An insignificant amount of hydrogen sulfide was removed by ground corncobs and chopped paper during the study. The removals that did occur may have resulted from absorption of hydrogen sulfide by the water that was applied to the materials to keep them moist. The removal rate would then depend on the rate that hydrogen sulfide dissolved in the water (23). It should be noted that data from only one of the columns containing paper were used in the analysis because the inlet line on the other column became clogged, thereby obstructing the flow of gas through the material. Even for the column that was used, difficulty was experienced in obtaining representative samples from the six, 12 and 18-inch levels because the sampling taps became clogged with the paper.

Sawdust, Styrofoam, and Elm Leaves

Although sawdust, styrofoam, and elm leaves exhibited poor hydrogen sulfide removal efficiencies, the efficiencies increased in a linear fashion throughout the duration of the study. The effect of styrofoam in removing hydrogen sulfide is characteristic of these materials and is depicted in Figure 4. From the figure, the gradual

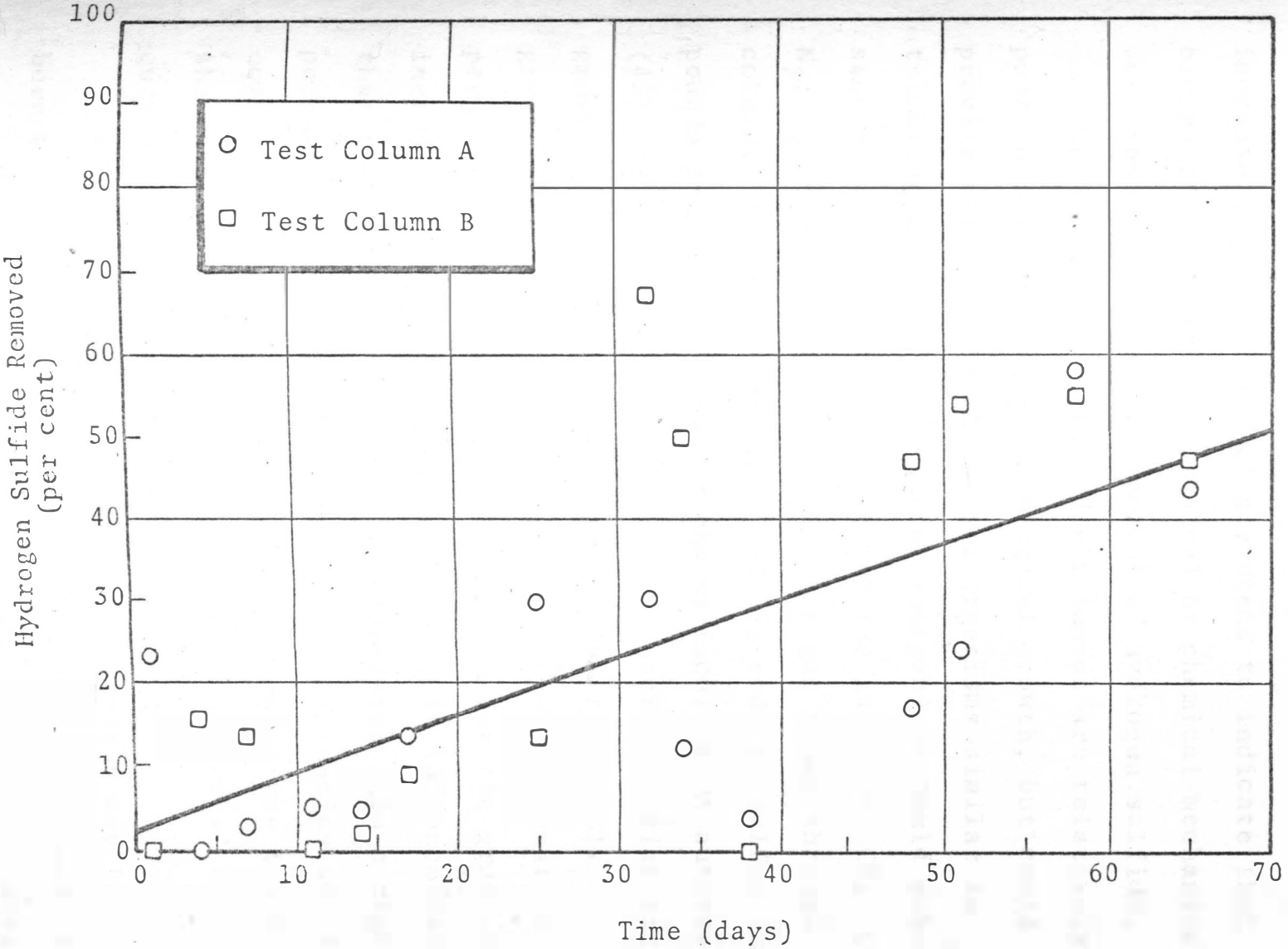


Figure 4. Hydrogen Sulfide Removal Efficiency as a Function of Time, Styrofoam

increase in removal efficiency seems to indicate that biological, rather than physical or chemical mechanisms were responsible for the removal of hydrogen sulfide.

Sawdust, styrofoam, and elm leaves are relatively poor substrates for microbiological growth, but could provide sites of attachment for organisms similar to trickling filter media. The microorganisms could subsequently utilize constituents of the gas (i.e. CH_4, CO_2, N_2, H_2S) in their metabolism as the gas flows through the column. The organisms which utilize reduced sulfur compounds are primarily autotrophs or facultative autotrophs (43) and therefore require little organic material for growth. Organisms of this nature have relatively low growth rates and therefore require longer acclimation periods. This might be an explanation for the gradual increase in removal efficiency. Thus, it is conceivable that these materials could be reclassified into a higher performance category if the removal efficiencies would continue to increase with time according to the trend shown in Figure 4. Longer operating times would be required to substantiate this possibility.

Physical or chemical removal mechanisms may have been effective initially in the elm leaves and sawdust as evidenced by the 20 per cent removal efficiencies attained on the first sampling date. Substances such as lignin,

present in wood and known to react with hydrogen sulfide, may have been responsible for the hydrogen sulfide removal. No removals occurred in the lower 18 inches of either material on the first day of sampling, but the initial tests were conducted 24 hours after start-up and breakthrough may have already occurred at these levels.

Alfalfa, Peat Moss, Straw, and Corncobs plus Manure

As shown in Figures 5-8, alfalfa, peat moss, straw, and the corncob-manure mixture all exhibited the same general pattern of hydrogen sulfide removal with respect to time. However, alfalfa and peat moss only reached a 50 per cent removal efficiency, whereas, the straw and corncob-manure mixture removed approximately 70 per cent of the hydrogen sulfide after 30 days of operation.

The manner in which removal efficiencies of these materials increased with time resembles the pattern that would be anticipated if biological removal mechanisms were active. Straw and the corncob-manure mixture exhibited approximately 25 per cent initial removals which would be indicative of chemical or physical mechanisms.

The asymtotic removal efficiencies that were obtained after several weeks of operation could be the result of a number of factors. For example, the maximum rate of hydrogen sulfide removal for a 24-inch bed of these materials may have been reached. In this case, a

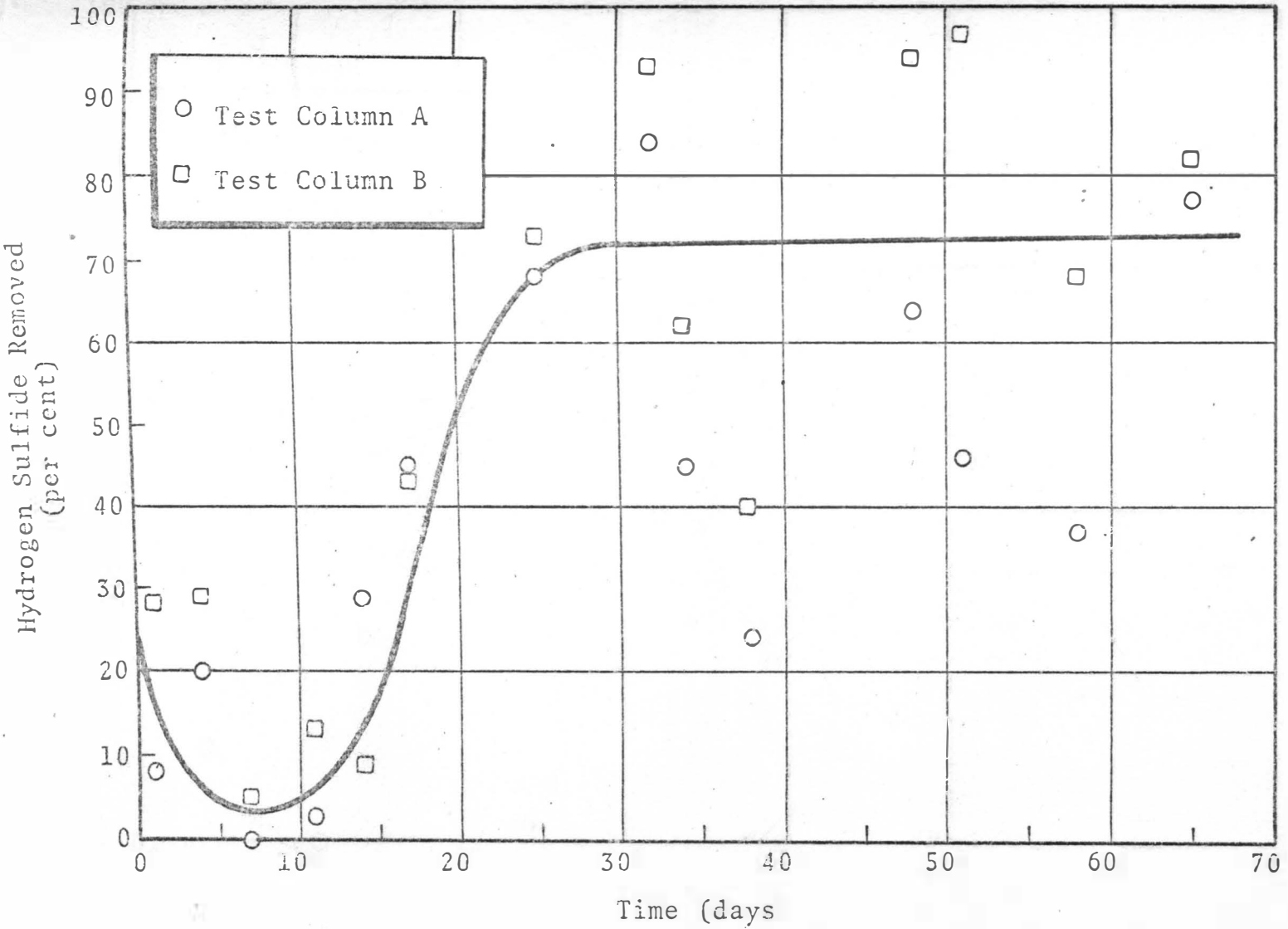


Figure 5. Hydrogen Sulfide Removal Efficiency as a Function of Time, Corncob-Manure Mixture

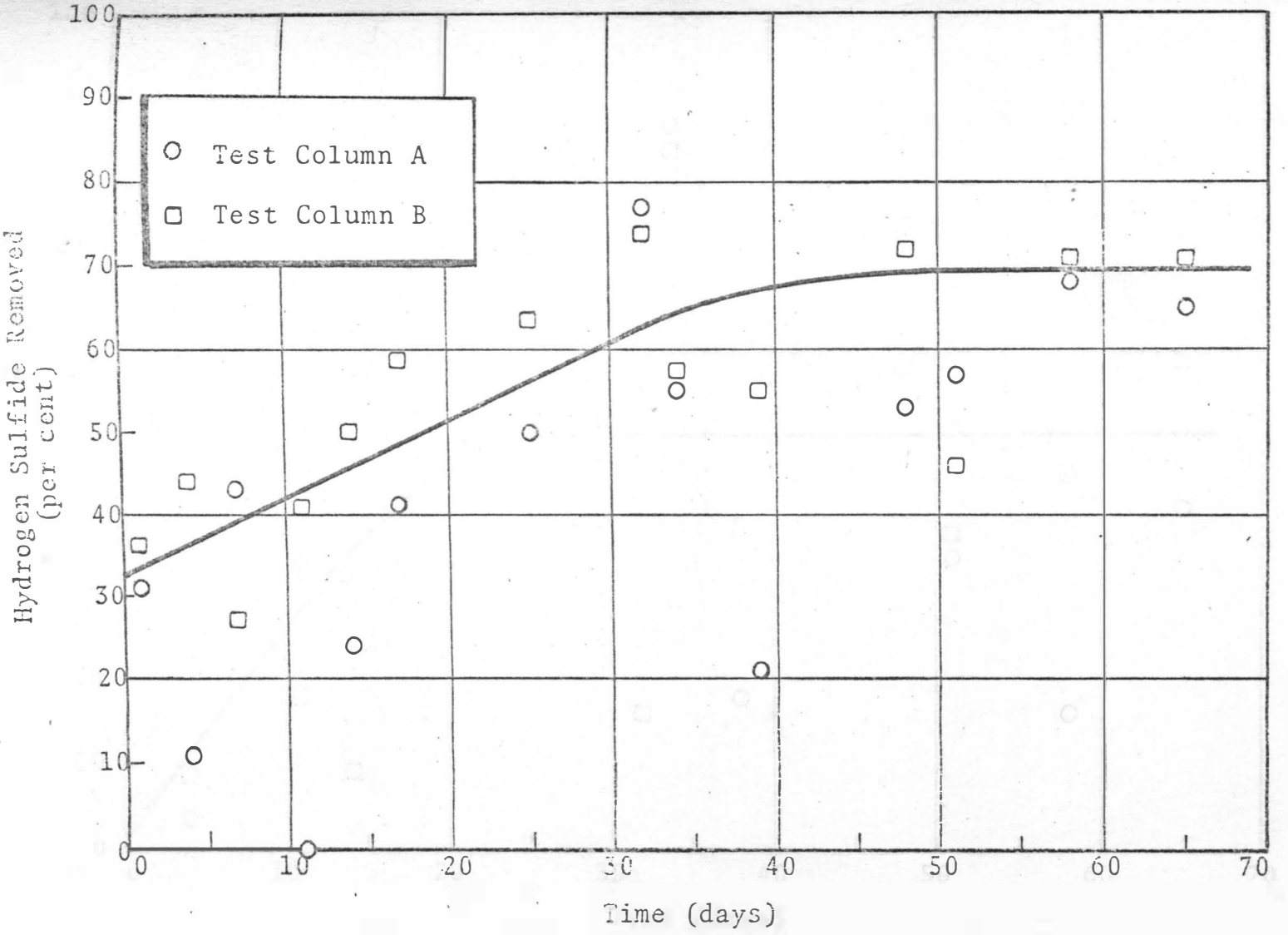


Figure 6. Hydrogen Sulfide Removal Efficiency as a Function of Time, Straw

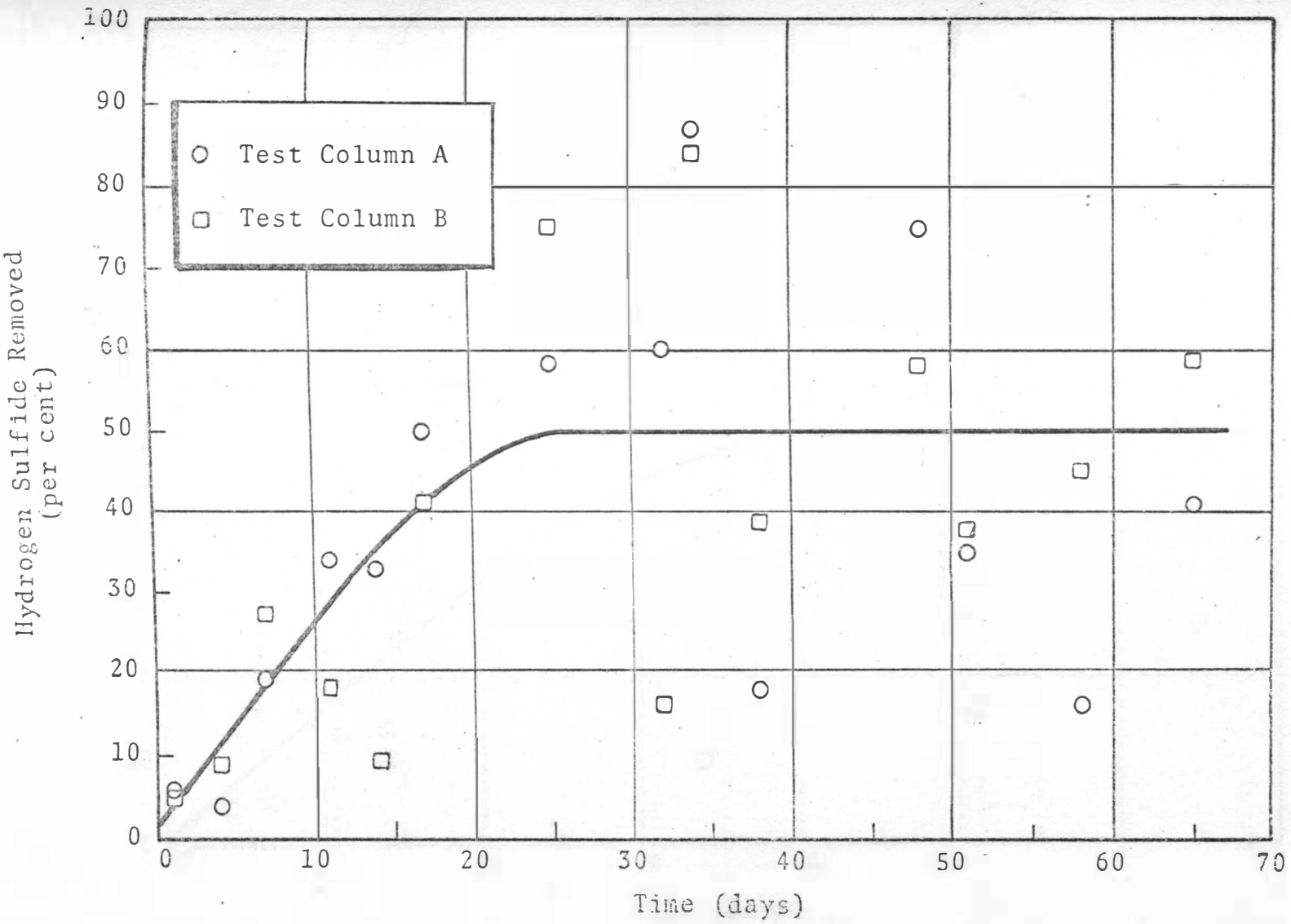


Figure 7. Hydrogen Sulfide Removal Efficiency as a Function of Time, Alfalfa

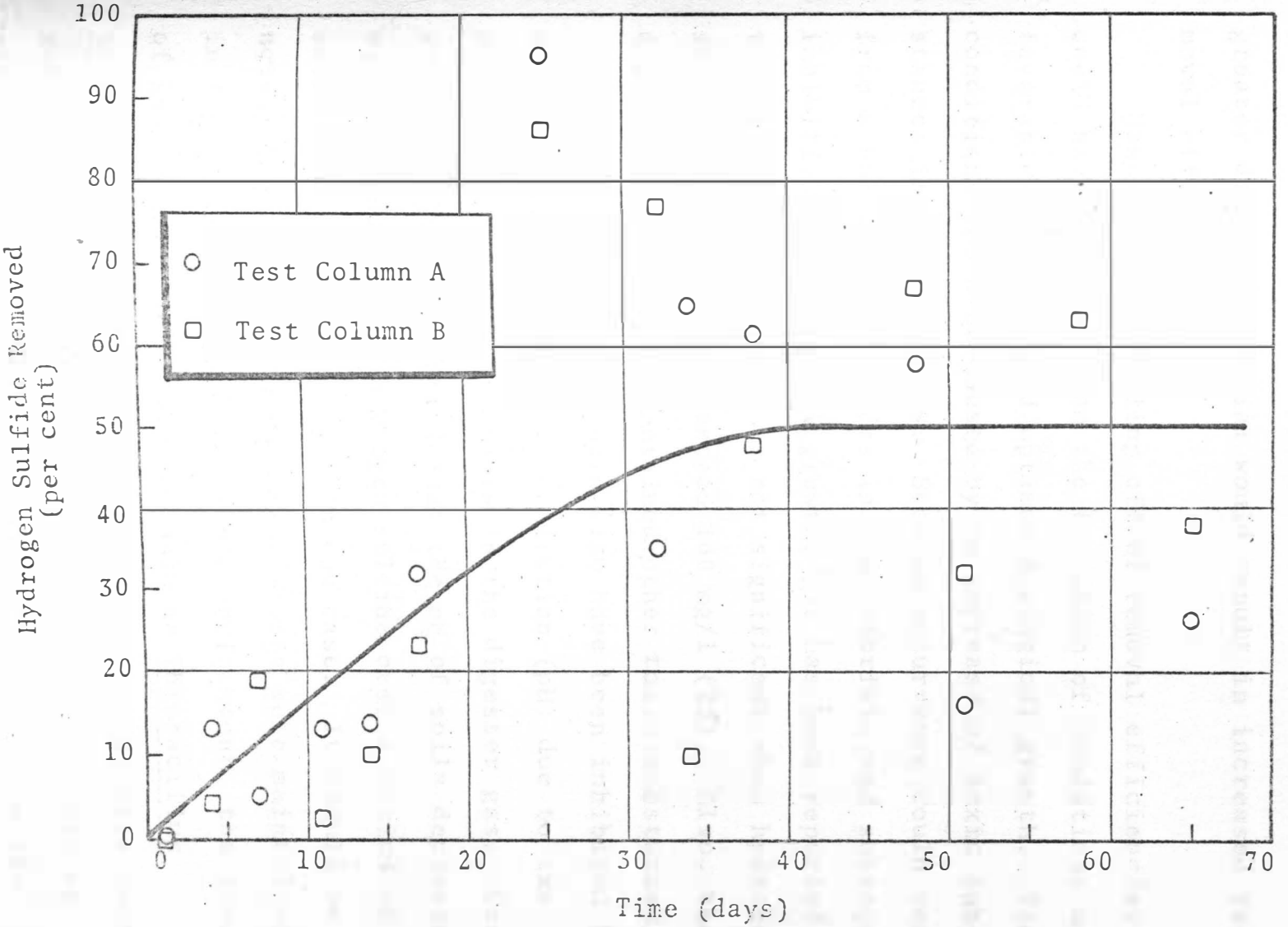


Figure 8. Hydrogen Sulfide Removal Efficiency as a Function of Time, Peat Moss

greater depth of material would result in increased removal efficiencies.

However, the leveling off of removal efficiencies could have resulted from the formation of conditions unfavorable for continued optimum biological growth. These conditions could be caused by an increase of toxic substances in the materials. Such an occurrence could result from a buildup of sulfides in the materials and subsequent inhibition of biological growth. It has been reported that biological removal is not significant when hydrogen sulfide concentrations exceed 100 mg/l (23). Also, the digester gas may have contained other toxic substances.

Biological growth could also have been inhibited by a shift in hydrogen ion concentration (pH) due to the presence of certain materials in the digester gas. Carlson and Leiser (22) noted that the pH of soils decreased with the addition of hydrogen sulfide over a period of several weeks, reaching 2.5 in one case. It should be noted, however, that aerobic conditions were maintained in their study, and in an aerobic environment, the growth of sulfur-oxidizing organisms such as Thiobacillus thiooxidans was possible. These organisms oxidize hydrogen sulfide forming sulfuric acid, and are capable of growing at a pH as low as one (42). However, in the studies described herein, a pH unfavorable for optimum

growth may have been developed due to the anaerobic environment that prevailed in the columns. A growth-limiting pH developed through natural fermentation may have developed in the columns containing straw or alfalfa.

The hydrogen ion concentration is important not only for biological reasons, but also because it influences the ionic equilibrium of hydrogen sulfide (48). As indicated in Figure 9, hydrogen sulfide dissociates with an increase in pH forming sulfhydryl or sulfide ions. Therefore, not much of the odorous undissociated hydrogen sulfide would exist in materials where the pH was above 8. Based on this pH relationship, the observations of Carlson et al. (23), who reported that soil at pH 8.0 removed more hydrogen sulfide than similar soil at pH 4.0 or 5.8, would be anticipated.

The pH of a material could be maintained either by buffering prior to its use, or by intermittent spraying with a basic pH solution (23). This would be particularly applicable at an installation where a basic wastewater was available, such as that from a caustic peeler in a potato plant.

Manure

As indicated in Figure 10, manure demonstrated an increasing percentage of hydrogen sulfide removal throughout the entire period of study. This material was

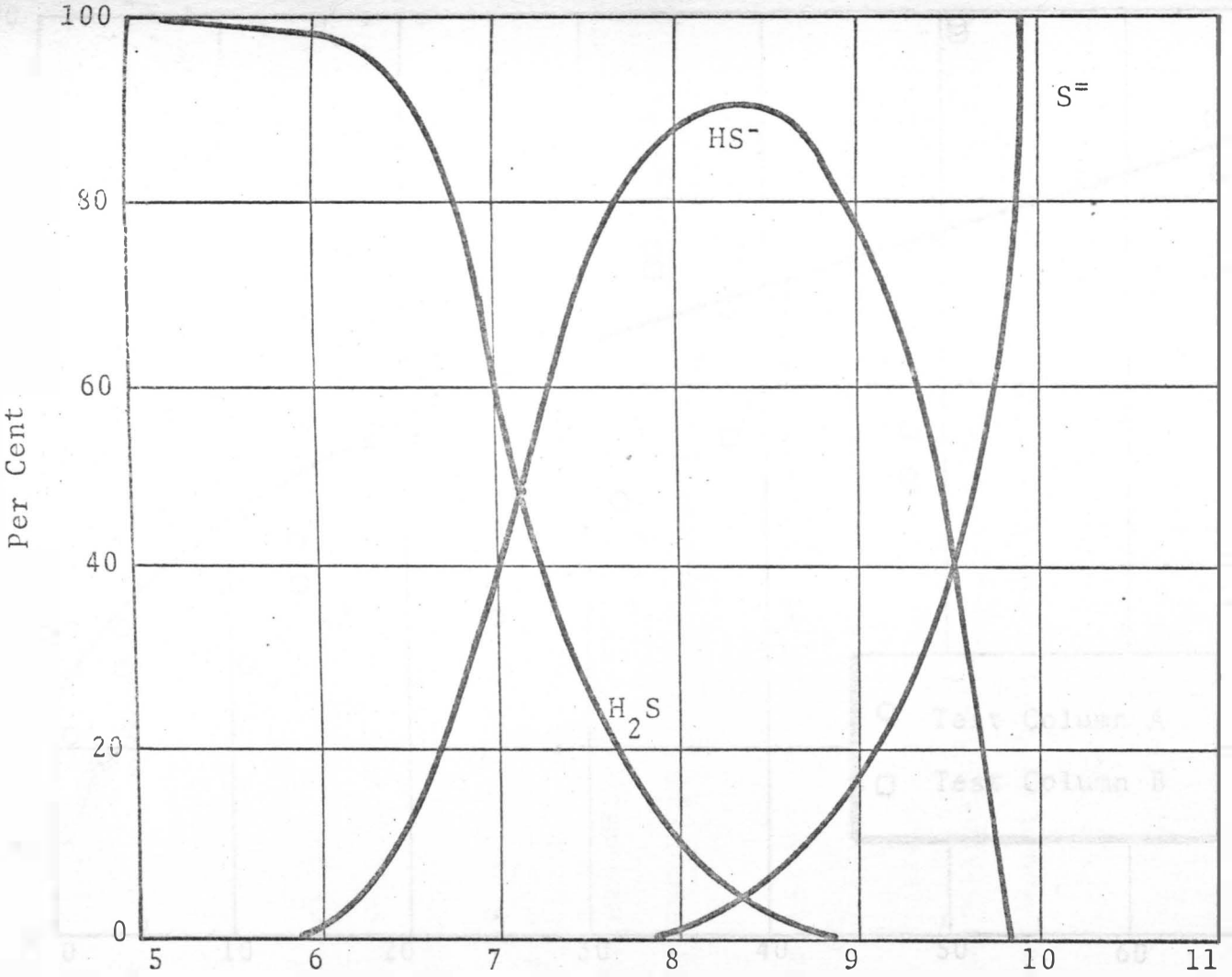


Figure 9. Effect of pH on Hydrogen Sulfide Equilibrium (47)

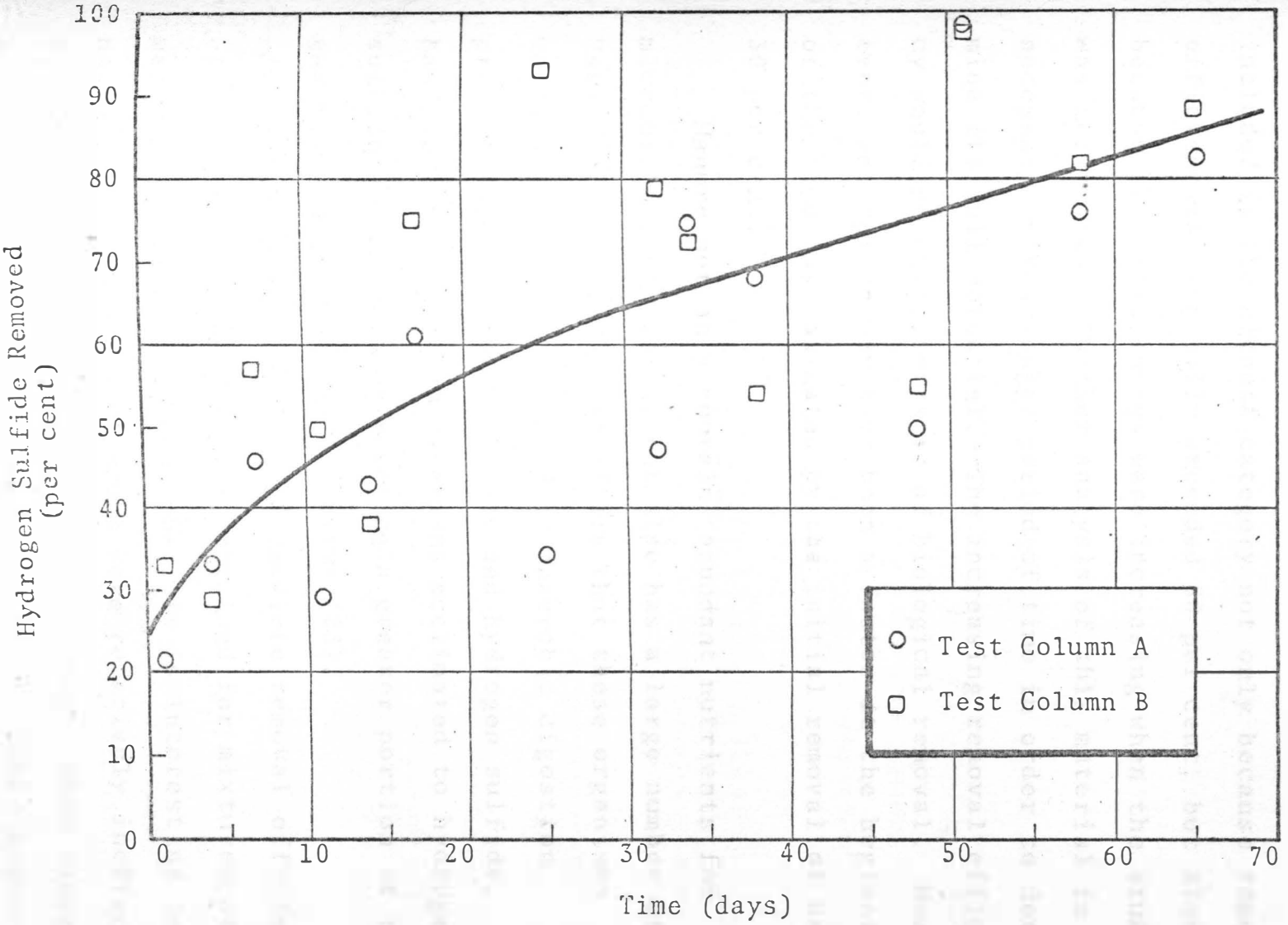


Figure 10. Hydrogen Sulfide Removal Efficiency as a Function of Time, Manure

included in the highest category not only because removal efficiencies eventually exceeded 80 per cent, but also because the efficiencies were increasing when the study was terminated. Further analysis of this material is necessary over a longer period of time in order to determine its full potential. The increasing removal efficiency would be characteristic of biological removal. However, adsorption may have been a factor at the beginning of the study as indicated by the initial removal of nearly 30 per cent.

Manure not only contains abundant nutrients for microbiological growth, but also has a large number of "seed" organisms. It is likely that these organisms would already be acclimated to anaerobic digestion products such as CO_2, methane, and hydrogen sulfide. It has been reported that organisms acclimated to hydrogen sulfide are capable of removing a greater portion of the gas than non-acclimated organisms (23).

As shown in Table 2, intermediate removal efficiencies (40 to 60 per cent) were obtained for mixtures of manure with sawdust or corncobs. It is interesting to note that sawdust and corncobs were relatively ineffective in removing hydrogen sulfide; however, when manure was combined with these materials, considerably higher removal efficiencies were obtained. This seems to verify

the statement by Carlson, et al. (23), that "with the addition of nutrients, materials such as vermiculite or synthetic products might serve well as filters by providing a loosely packed material which could facilitate gas and water flows."

Soil, Wood chips, Scum layer, and Sawdust plus Manure

The manure-sawdust mixture, loam soil, scum layer, and wood chips all exhibited removal efficiencies which varied with time according to quartic functions. A typical response of this type is presented in Figures 11 and 12, which are the plots for the manure-sawdust mixture and soil.

The quartic response was not confined to materials exhibiting the same general range of removal efficiencies, but rather existed in materials with high, intermediate, and low removal efficiencies. However, with the exception of the wood chips, these materials all attained removal efficiencies in excess of 90 per cent for a period of time during the study.

Changes in temperature and flow rate were considered as possible causes of the oscillation, but careful study of these factors indicated no correlation, although some changes in flow and temperature occurred. The average daily temperature (Appendix IV) decreased approximately 6°F during the period of study, and this small decrease

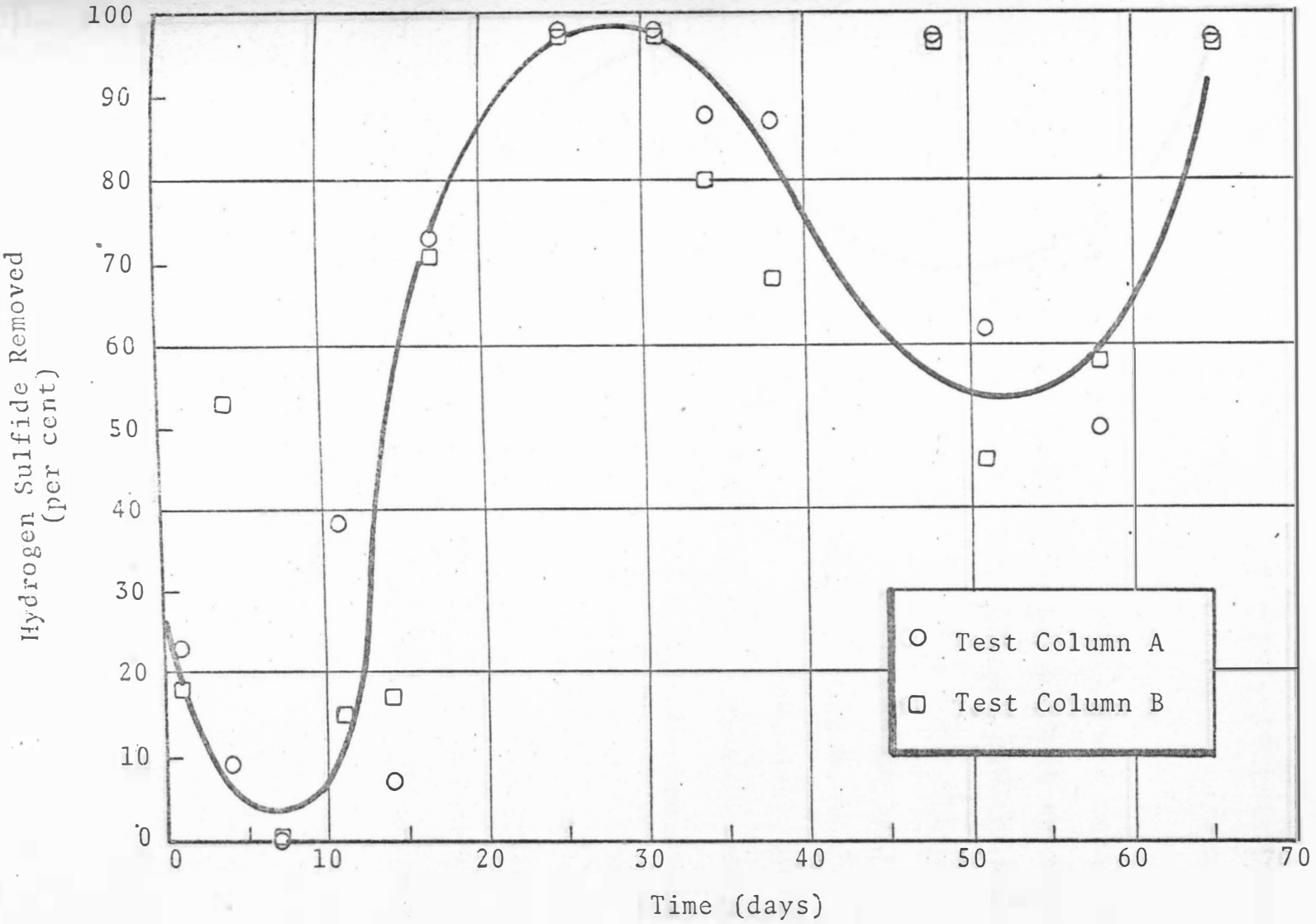


Figure 11. Hydrogen Sulfide Removal Efficiency as a Function of Time, Sawdust-Manure Mixture

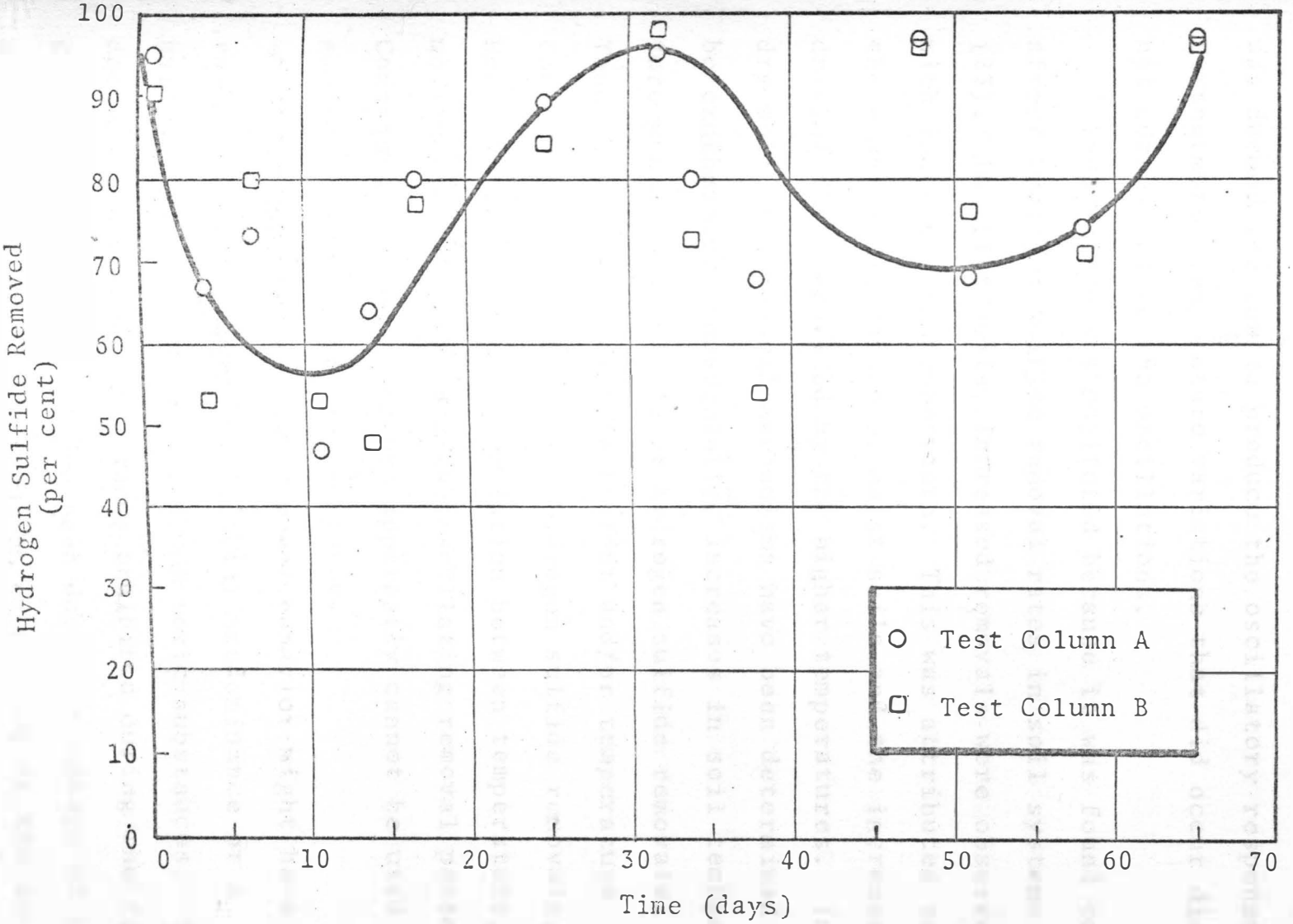


Figure 12. Hydrogen Sulfide Removal Efficiency as a Function of Time, Soil

was deemed too low to produce the oscillatory response. Furthermore, temperature variations that did occur did not correspond to the oscillations.

Temperature was monitored because it was found to affect hydrogen sulfide removal rates in soil systems (23). In moist soils, increased removals were observed with increases in temperature. This was attributed to the endothermic nature of moist soils and the increased driving force provided by the higher temperatures. In dry soil, the removal mechanisms have been determined to be exothermic. Consequently, increases in soil temperature would result in lower hydrogen sulfide removals. Thus, changes in moisture content and/or temperature could result in oscillating hydrogen sulfide removals. However, there was no correlation between temperature, moisture conditions, and the oscillating removal pattern. Consequently, these factors apparently cannot be used to explain the observed time response.

The oscillatory time-removal behavior might have resulted from a shift in microbial predominance or a buildup and subsequent removal of toxic substances. The decrease in removal efficiency exhibited during the first week of sampling could have been due to a leakage of hydrogen sulfide resulting from an exhaustion of the adsorptive capacity of the material. The second decrease

in removal efficiency could be attributed to a predominance shift or inhibition from an increase in toxic substances.

The sawdust-manure mixture would have been considered the most effective odor-reducing material tested if the removal efficiency had not decreased during the last two weeks of the study. However, it can be seen from Figure 11, that only one data point was obtained which could be interpreted as a return to high-performance removal, otherwise, the material would have been given a low rating. Nonetheless, this material achieved hydrogen sulfide removals in excess of 75 per cent nearly half of the time, and on four days, removals of 98 per cent were achieved. Therefore, further testing of this mixture would seem warranted.

After three weeks of the study had elapsed, hydrogen sulfide removals for the anaerobic lagoon scum layer ranged between 60 and 80 per cent. Scum layers have been reported to be effective in reducing or eliminating odors from anaerobic lagoons treating meat packing wastes (5, 6, 7, 8). These findings would appear to be substantiated by the studies described herein. However, a finite pressure gradient is required for gas transport through the scum and this pressure may also prevent a portion of the gas from escaping, thereby contributing to a reduction

of odors. Hydrogen sulfide retained in the anaerobic lagoon effluent would be oxidized in the aerobic environment of the aerated lagoons which normally follow anaerobic systems, reducing the odor. In addition, if the pH of the aerated lagoon was above 8, nearly all the hydrogen sulfide would disassociate forming sulfhydryl ions.

From the plot of hydrogen sulfide removal efficiency for soil versus time, presented in Figure 12, it can also be seen that the removal efficiency of the loamy soil fluctuated, but remained near 80 per cent. Carlson and Leiser (22) reported a 92 per cent reduction in hydrogen sulfide through the bottom 24 inches of their soil column for a flow rate of 0.34 cfm/ft^2 and a hydrogen sulfide concentration of 9.5 mg/l. For approximately the same conditions, except for flow which was about 50 per cent lower, removals of about 80 per cent were obtained for studies described herein.

It is likely that aerobic conditions existed in the columns of Carlson and Leiser because air was used to transport the hydrogen sulfide. Thus, aerobic sulfur bacteria such as Thiobacillus thiooxidans could have oxidized the sulfides to sulfates. Furthermore, data from their investigations would appear to substantiate the presence of aerobic biological oxidation since sulfates increased in the soil from 298 mg/l at the beginning of

the study to 2120 mg/l after three weeks. In contrast to the work of Carlson and Leiser, it is believed that conditions within the columns used for the investigations described herein were primarily anaerobic. It is likely that aerobic conditions existed only at the top of the material because the columns were uncovered. Soil was rated in the high removal category because the removal efficiency for this material was consistently high.

Hydrogen Sulfide Removal as a Function of Depth

The median hydrogen sulfide removal efficiencies at depths of six, 12, 18 and 24 inches for selected materials after 32 days of study, are presented in Table 3, and for the remaining materials, in Appendix V. The range of efficiencies are shown in the parenthesis. With the exception of straw, soil, and the manure mixtures, practically all the hydrogen sulfide was removed in the top six inches of material. This seems to indicate that aerobic, rather than anaerobic biological mechanisms were responsible for the hydrogen sulfide removal. The columns were not covered so aerobic conditions probably existed at the top of the columns permitting the growth of aerobic sulfur-oxidizing microorganisms.

Very little hydrogen sulfide was removed in the lower depths of the columns in which the environment was anaerobic. This finding would be anticipated because

Table 3

Hydrogen Sulfide Removal Efficiencies for Selected Materials According to Depth During the Last 33 Days of the Study

Material	Depth From Bottom of Column, inches			
	6	12	18	24
Soil	29.6[1] (0.0-97.1)[2]	18.0 (0.0-97.2)	23.8 (2.3-97.2)	77.8 (54.5-97.7)
Sawdust	0.0 (0.0-26.5)	1.2 (0.0-42.1)	13.8 (2.3-44.2)	51.6 (13.6-73.5)
Alfalfa	0.0 (0.0-15.0)	3.9 (0.0-17.0)	14.8 (0.0-32.5)	43.0 (15.8-87.5)
Manure	0.0 (0.0-11.8)	0.0 (0.0-41.2)	2.6 (0.0-82.4)	77.7 (46.5-97.3)
Straw	0.0 (0.0)	2.6 (0.0-8.8)	21.8 (2.6-61.8)	61.1 (21.1-76.7)
Corncobs plus Manure	0.0 (0.0-76.7)	6.7 (0.0-93.0)	17.6 (0.0-95.3)	66.2 (23.7-97.3)
Sawdust plus Manure	1.4 (0.0-41.9)	5.3 (0.0-58.8)	31.1 (5.0-97.1)	87.2 (45.9-97.7)

[1] Median value for last 33 days of study

[2] Range for last 33 days of study

relatively few anaerobic organisms are known to be capable of utilizing reduced sulfur as an energy source (42). In addition, the anaerobic organisms with this capability are primarily photosynthetic (42). The growth of these

organisms was prevented since the columns were opaque and housed so that none of the materials were exposed to either direct or indirect sunlight. Consequently, growth of photosynthetic organisms below the surface of the materials would be highly improbable.

As shown in Table 3, sawdust and alfalfa, which were rated low in Table 2, exhibited substantial removal efficiencies at the 18-inch level near the end of the study. There are very few non-photosynthetic anaerobes, if any, that will convert sulfides to elemental sulfur. However, if such organisms were present, it is possible that an extensive acclimation period was necessary to allow a sufficient number of them to grow to remove any significant amount of hydrogen sulfide. Studies over a longer period of time and at greater depths are warranted for these materials.

Very little hydrogen sulfide was removed in the lower 12 inches of straw, a material rated at the intermediate level. However, as indicated in Table 3, the next six inches accounted for nearly 20 per cent of the total removed. The straw was packed loosely in the column, so aerobic conditions may have existed in the top 12 inches of the material. Aerobic conditions would permit the growth of the more efficient aerobic sulfur bacteria.

A significant amount of hydrogen sulfide was removed

in the top 18 inches of the manure mixtures during the last month of study. These materials were fairly dense and aerobic conditions would have been difficult to maintain below the surface of the materials. Thus, it would appear that anaerobic, rather than aerobic biological mechanisms were responsible for the hydrogen sulfide removal. Thiobacillus denitrificans is a facultative anaerobe capable of utilizing reduced sulfur in its metabolism (42). However, nitrates are also required as an electron acceptor. Nitrates are not normally present in digester gas, but the manure may have supplied sufficient nitrates for the growth of these organisms, which could have resulted in hydrogen sulfide removals at the lower depths. Unfortunately, the manure was not analyzed for nitrates during the study. It should be noted, however, that for the columns containing manure only, there was very little hydrogen sulfide removed in the first 18 inches until the final two weeks of study. At this time, approximately 45 per cent of the total hydrogen sulfide removal occurred in the lower 18 inches of the columns.

Hydrogen sulfide was removed at all depths in the soil, with the major fractions being removed in the top six inches and bottom six inches of material. The highest removal efficiency obtained in the lower 12 inches

of soil never exceeded 40 per cent, compared with the 60 per cent removal in this same region for loamy soil reported by Carlson, et al. (23). Adsorption was indicated initially at all depths, but biological mechanisms appeared to predominate during the remainder of the study.

Finally, it is evident from Table 3 that the materials which demonstrated the highest hydrogen sulfide removal efficiencies were those believed most likely to be capable of supporting biological growth. These results are similar to those presented for removals as a function of time.

ENGINEERING APPLICATION

The results of these studies were used to propose a system that would reduce odors generated by an anaerobic lagoon. The system would consist of three-inch styrofoam sheets floated on the water surface and covered with either straw, manure, or a mixture of sawdust and manure. The most appropriate thickness for straw would be 36 inches, for manure 12 inches, and 24 inches of thickness would be required for the sawdust-manure mixture. These materials are readily available at a low cost, and have proven to be effective in removing hydrogen sulfide. The material should be blown onto the lagoon to insure a uniform thickness. The material should be maintained in a moist condition by spraying with aerated lagoon water every two weeks, or when required. Aerated lagoon water will provide seed organisms, nutrients, and a pH buffer, and also prevent the wind from disturbing the material.

CONCLUSIONS

Based upon the investigations described herein, the following conclusions were made:

1. Chopped paper, corncobs, styrofoam, peat moss, alfalfa, elm leaves, sawdust, and wood chips exhibited hydrogen sulfide removal efficiencies below 60 per cent during the period of study. However, the removal efficiencies for styrofoam, sawdust, and elm leaves all increased with time during the period of study.
2. The hydrogen sulfide removal efficiencies for straw, anaerobic-lagoon surface scum, and the manure mixtures ranged between 60-75 per cent after one month of operation. For straw and the manure mixtures, increased removals might be achieved by using layers of these materials greater than 24 inches.
3. Soil and manure were found to be most effective in removing hydrogen sulfide from digester gas during the period of study, having removal efficiencies greater than 75 per cent. The full potential of manure was not determined because the removal efficiencies of this material continued to increase throughout the entire study period so that an estimate of the ultimate

maximum removal could not be made.

4. The anaerobic lagoon scum layer also removed a substantial amount of hydrogen sulfide.
5. Biological filters appear to be effective and inexpensive methods of reducing hydrogen sulfide concentrations; however, continued study under controlled conditions is necessary to more completely define the performance potential and removal mechanisms of the media.
6. Based on the gradual increase in removal efficiency with time and the fact that the majority of the hydrogen sulfide was removed in the top six inches of all the materials tested, it is concluded that biological rather than physical or chemical mechanisms were responsible for the removal of the hydrogen sulfide and that aerobic rather than anaerobic microbes were the predominant organisms responsible for the hydrogen sulfide removal.
7. Greater hydrogen sulfide removal efficiencies would be attained if aerobic conditions were maintained in the materials.

RECOMMENDATIONS FOR FUTURE STUDY

1. The following materials merit additional study, using greater thicknesses and longer periods of investigation:

    a. Sawdust
    b. Straw
    c. Corncobs plus manure
    d. Sawdust plus manure
    e. Manure
    f. Anaerobic lagoon scum layer

2. Future studies should be conducted under laboratory rather than field conditions in order that a constant flow, pressure and temperature of gas may be maintained. Rotameters should be used in conjunction with needle valves to gage and control the gas flow rate to each column, thereby eliminating the time required to recalibrate needle valves. The temperature should also be held constant at a level suitable for optimum biological growth.

3. A source of hydrogen sulfide gas other than digester gas should be utilized so the hydrogen sulfide concentration may be controlled. Carbon dioxide should be used as the carrier. In this way, anaerobic conditions may be maintained and the explosion hazard eliminated. An inorganic carbon source, such as

carbon dioxide could also serve as a substrate for the microorganisms.

4. The gas inlet tubing should be tapped into the column wall near the bottom rather than into the bottom of the column. This will allow gas to flow upward through the materials, but will prevent the water added to moisten the materials from collecting in the gas tubing and impeding the gas flow.
5. The columns should be covered to prevent any aeration in the upper levels of the materials. Strict anaerobic conditions may then be maintained to determine if non-photosynthetic anaerobic organisms will remove hydrogen sulfide. The effect of aerobic conditions could still be analyzed by injecting air into the materials through the sampling taps at various depths.
6. The materials should be tested at a depth of four feet with sampling taps located at increments of 12 inches rather than six inches. Locating the sampling taps at one foot increments will allow the changes due to depth to be more clearly determined.
7. Microbiological analyses should be conducted to determine the type and identity of the microorganisms responsible for removal of hydrogen sulfide.
8. A more accurate method of hydrogen sulfide analyses should be used, if available, so that hydrogen

sulfide concentrations as low as 0.02 mg/1, which approaches the threshhold limit of hydrogen sulfide, may be measured.

9. Analyses of the materials should be conducted to determine the changes in sulfate concentrations and pH that occur with continued application of hydrogen sulfide.

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APPENDIX I

Description of Materials

Material	Description
Chopped paper	Newsprint cut into one-inch squares
Soil	Loamy soil
Corncobs	Corncobs ground to approximately ¼-inch diameter
Sawdust	Sawdust from kiln-dried lumber
Alfalfa	Chopped alfalfa
Peat moss	
Manure	Cow manure from local feedlot
Styrofoam	Styrofoam chopped to approximately ¼-inch diameter
Straw	Straw cut into two inch lengths
Corncobs plus manure	Mixture of 60% ground corncobs and 40% manure by weight
Elm leaves	Mulched elm leaves
Sawdust plus manure	Mixture of 60% sawdust and 40% manure by weight
Wood chips	Branches passed through wood chipper
Scum layer	Scum layer from the anaerobic lagoon, Iowa Beef Packing Plant, Luverne, Minnesota

APPENDIX II

Performance Data

EXPLANATION OF TABLE HEADINGS

	INPUT		REMOVAL AT 6 IN.		
TREAT[1]	GR/[2] 100 CF	MG/[3] DAY	GR/[4] 100 CF	MG/[5] DAY	PER[6] CENT
1-1[7]	390.0	7798.1	290.0	5798.6	25.6
1-2[7]	390.0	0.0*	0.0*	0.0*	0.0*
	etc.		etc.		etc.

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[1]Treatments

1. Chopped paper
2. Soil
3. Corncobs
4. Sawdust
5. Alfalfa
6. Peat moss
7. Manure
8. Styrofoam
9. Straw
10. Corncobs plus manure
11. Elm leaves
12. Sawdust plus manure
13. Wood chips
14. Anaerobic lagoon scum layer

[2]Input H_2S concentration, (grains/100 cubic feet)

[3]Input rate, (milligrams/day)

[4]Concentration of H_2S remaining, (grains/100 cubic feet)

[5]H_2S discharged, (milligrams/day)

[6]H_2S removed, (per cent)

[7]Duplicate columns of material; 1 refers to Test Column A, 2 refers to Test Column B

*Denotes missing data

SEPT 1

TREAT	INPUT GR/ 100 CF	INPUT MG/ DAY	REMOVAL AT 6 IN. GR/ 100 CF	REMOVAL AT 6 IN. MG/ DAY	REMOVAL AT 6 IN. PER CENT	REMOVAL AT 12 IN. GR/ 100 CF	REMOVAL AT 12 IN. MG/ DAY	REMOVAL AT 12 IN. PER CENT	REMOVAL AT 18 IN. GR/ 100 CF	REMOVAL AT 18 IN. MG/ DAY	REMOVAL AT 18 IN. PER CENT	REMOVAL AT 24 IN. GR/ 100 CF	REMOVAL AT 24 IN. MG/ DAY	REMOVAL AT 24 IN. PER CENT	FLOW (CFM)
1-1	390.0	7798.1	290.0	5798.6	25.6	320.0	6398.4	17.9	290.0	5798.6	25.6	320.0	6398.4	17.9	0.021
1-2	390.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-1	390.0	5933.3	330.0	5020.5	15.4	200.0	3042.7	48.7	50.0	760.7	87.2	20.0	304.3	94.9	0.016
2-2	390.0	6909.7	360.0	6378.2	7.7	300.0	5315.1	23.1	120.0	2126.1	69.2	40.0	708.7	89.7	0.019
3-1	390.0	6203.0	390.0	6203.0	0.0	390.0	6203.0	0.0	390.0	6203.0	0.0	330.0	5248.7	15.4	0.017
3-2	390.0	6498.4	390.0	6498.4	0.0	390.0	6498.4	0.0	390.0	6498.4	0.0	350.0	5831.9	10.3	0.018
4-1	390.0	6823.3	390.0	6823.3	0.0	390.0	6823.3	0.0	390.0	6823.3	0.0	270.0	4723.8	30.8	0.019
4-2	390.0	6739.1	390.0	6739.1	0.0	390.0	6739.1	0.0	390.0	6739.1	0.0	330.0	5702.3	15.4	0.019
5-1	390.0	7278.2	380.0	7091.6	2.6	380.0	7091.6	2.6	390.0	7278.2	0.0	370.0	6905.0	5.1	0.020
5-2	390.0	7089.2	390.0	7089.2	0.0	390.0	7089.2	0.0	390.0	7089.2	0.0	370.0	6725.6	5.1	0.019
6-1	390.0	7278.2	390.0	7278.2	0.0	390.0	7278.2	0.0	390.0	7278.2	0.0	390.0	7278.2	0.0	0.020
6-2	390.0	7182.4	390.0	7182.4	0.0	390.0	7182.4	0.0	390.0	7182.4	0.0	390.0	7182.4	0.0	0.020
7-1	390.0	5198.7	390.0	5198.7	0.0	390.0	5198.7	0.0	390.0	5198.7	0.0	310.0	4132.3	20.5	0.014
7-2	390.0	3688.3	390.0	3688.3	0.0	390.0	3688.3	0.0	390.0	3688.3	0.0	260.0	2458.9	33.3	0.010
8-1	390.0	2228.0	390.0	2228.0	0.0	390.0	2228.0	0.0	390.0	2228.0	0.0	300.0	1713.9	23.1	0.006
8-2	390.0	6421.9	390.0	6421.9	0.0	390.0	6421.9	0.0	390.0	6421.9	0.0	390.0	6421.9	0.0	0.018
9-1	390.0	6656.9	390.0	6656.9	0.0	390.0	6656.9	0.0	350.0	5974.1	10.3	270.0	4608.6	30.8	0.018
9-2	390.0	6656.9	390.0	6656.9	0.0	390.0	6656.9	0.0	340.0	5803.4	12.8	250.0	4267.2	35.9	0.018
10-1	390.0	5998.5	390.0	5998.5	0.0	390.0	5998.5	0.0	390.0	5998.5	0.0	360.0	5537.1	7.7	0.016
10-2	390.0	6065.2	390.0	6065.2	0.0	390.0	6065.2	0.0	370.0	5754.1	5.1	280.0	4354.5	28.2	0.017
11-1	390.0	6274.3	390.0	6274.3	0.0	390.0	6274.3	0.0	360.0	5791.7	7.7	300.0	4826.4	23.1	0.017
11-2	390.0	6203.0	390.0	6203.0	0.0	390.0	6203.0	0.0	390.0	6203.0	0.0	160.0	2544.8	59.0	0.017
12-1	390.0	3984.4	390.0	3984.4	0.0	390.0	3984.4	0.0	360.0	3677.9	7.7	300.0	3064.9	23.1	0.011
12-2	390.0	7089.2	390.0	7089.2	0.0	390.0	7089.2	0.0	380.0	6907.4	2.6	320.0	5816.8	17.9	0.019
13-1	390.0	6065.2	390.0	6065.2	0.0	390.0	6065.2	0.0	390.0	6065.2	0.0	290.0	4510.0	25.6	0.017
13-2	390.0	16054.9	390.0	16054.9	0.0	390.0	16054.9	0.0	360.0	14819.9	7.7	280.0	11526.6	28.2	0.044
14-1	390.0	6065.2	390.0	6065.2	0.0	390.0	6065.2	0.0	380.0	5909.7	2.6	170.0	2643.8	56.4	0.017
14-2	390.0	7911.1	390.0	7911.1	0.0	390.0	7911.1	0.0	380.0	7708.3	2.6	230.0	4665.5	41.0	0.022

SEPT 3E4

TREAT	INPUT GR/ 100 CF	INPUT MG/ DAY	REMOVAL AT 6 IN. GR/ 100 CF	REMOVAL AT 6 IN. MG/ DAY	REMOVAL AT 6 IN. PER CENT	REMOVAL AT 12 IN. GR/ 100 CF	REMOVAL AT 12 IN. MG/ DAY	REMOVAL AT 12 IN. PER CENT	REMOVAL AT 18 IN. GR/ 100 CF	REMOVAL AT 18 IN. MG/ DAY	REMOVAL AT 18 IN. PER CENT	REMOVAL AT 24 IN. GR/ 100 CF	REMOVAL AT 24 IN. MG/ DAY	REMOVAL AT 24 IN. PER CENT	FLOW (CFM)
1-1	450.0	8747.9	450.0	8747.9	0.0	450.0	8747.9	0.0	440.0	8553.5	2.2	420.0	8164.7	6.7	0.021
1-2	450.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-1	450.0	6493.3	370.0	5338.9	17.8	280.0	4040.2	37.8	310.0	4473.1	31.1	150.0	2164.4	66.7	0.015
2-2	450.0	8074.9	420.0	7536.6	6.7	380.0	6818.8	15.6	360.0	6459.9	20.0	210.0	3768.3	53.3	0.019
3-1	450.0	6998.3	450.0	6998.3	0.0	450.0	6998.3	0.0	450.0	6998.3	0.0	360.0	5598.6	20.0	0.017
3-2	450.0	7157.3	450.0	7157.3	0.0	450.0	7157.3	0.0	450.0	7157.3	0.0	410.0	6521.1	8.9	0.017
4-1	450.0	7775.9	450.0	7775.9	0.0	450.0	7775.9	0.0	450.0	7775.9	0.0	450.0	7775.9	0.0	0.019
4-2	450.0	7239.6	450.0	7239.6	0.0	450.0	7239.6	0.0	450.0	7239.6	0.0	450.0	7239.6	0.0	0.017
5-1	450.0	7873.1	450.0	7873.1	0.0	450.0	7873.1	0.0	440.0	7698.1	2.2	430.0	7523.2	4.4	0.019
5-2	450.0	8179.8	450.0	8179.8	0.0	450.0	8179.8	0.0	450.0	8179.8	0.0	410.0	7452.7	8.9	0.019
6-1	450.0	7775.9	450.0	7775.9	0.0	450.0	7775.9	0.0	450.0	7775.9	0.0	390.0	6739.1	13.3	0.019
6-2	450.0	8628.0	450.0	8628.0	0.0	450.0	8628.0	0.0	450.0	8628.0	0.0	430.0	8244.5	4.4	0.021
7-1	450.0	10325.3	450.0	10325.3	0.0	450.0	10325.3	0.0	440.0	10095.9	2.2	300.0	6883.6	33.3	0.025
7-2	450.0	10158.8	450.0	10158.8	0.0	450.0	10158.8	0.0	440.0	9933.0	2.2	320.0	7224.0	28.9	0.024
8-1	450.0	7681.0	450.0	7681.0	0.0	450.0	7681.0	0.0	450.0	7681.0	0.0	450.0	7681.0	0.0	0.018
8-2	450.0	7498.2	450.0	7498.2	0.0	450.0	7498.2	0.0	450.0	7498.2	0.0	380.0	6331.8	15.6	0.018
9-1	450.0	6115.0	450.0	6115.0	0.0	450.0	6115.0	0.0	440.0	5979.1	2.2	400.0	5435.6	11.1	0.015
9-2	450.0	7498.2	450.0	7498.2	0.0	430.0	7164.9	4.4	410.0	6831.7	8.9	250.0	4165.6	44.4	0.018
10-1	450.0	7498.2	430.0	7164.9	4.4	420.0	6998.3	6.7	430.0	7164.9	4.4	360.0	5998.5	20.0	0.018
10-2	450.0	6629.9	430.0	6335.3	4.4	420.0	6188.0	6.7	410.0	6040.6	8.9	320.0	4714.6	28.9	0.016
11-1	450.0	6998.3	430.0	6687.2	4.4	360.0	5598.6	20.0	390.0	6065.2	13.3	290.0	4510.0	35.6	0.017
11-2	450.0	7076.9	450.0	7076.9	0.0	450.0	7076.9	0.0	440.0	6919.6	2.2	310.0	4875.2	31.1	0.017
12-1	450.0	11049.9	450.0	11049.9	0.0	450.0	11049.9	0.0	440.0	10804.4	2.2	410.0	10067.7	8.9	0.026
12-2	450.0	8397.9	450.0	8397.9	0.0	450.0	8397.9	0.0	440.0	8211.3	2.2	210.0	3919.0	53.3	0.020
13-1	450.0	6998.3	450.0	6998.3	0.0	430.0	6687.2	4.4	380.0	5909.7	15.6	250.0	3887.9	44.4	0.017
13-2	450.0	10859.4	450.0	10859.4	0.0	450.0	10859.4	0.0	430.0	10376.8	4.4	400.0	9652.8	11.1	0.026
14-1	450.0	7498.2	450.0	7498.2	0.0	430.0	7164.9	4.4	370.0	6165.2	17.8	200.0	3332.5	55.6	0.018
14-2	450.0	10158.8	450.0	10158.8	0.0	450.0	10158.8	0.0	400.0	9030.0	11.1	240.0	5418.0	46.7	0.024

SEPT 7

TREAT	INPUT GR/ 100 CF	INPUT MG/ DAY	REMOVAL AT 6 IN. GR/ 100 CF	REMOVAL AT 6 IN. MG/ DAY	REMOVAL AT 6 IN. PER CENT	REMOVAL AT 12 IN. GR/ 100 CF	REMOVAL AT 12 IN. MG/ DAY	REMOVAL AT 12 IN. PER CENT	REMOVAL AT 18 IN. GR/ 100 CF	REMOVAL AT 18 IN. MG/ DAY	REMOVAL AT 18 IN. PER CENT	REMOVAL AT 24 IN. GR/ 100 CF	REMOVAL AT 24 IN. MG/ DAY	REMOVAL AT 24 IN. PER CENT	FLOW (CFM)
1-1	370.0	7505.4	370.0	7505.4	0.0	370.0	7505.4	0.0	260.0	5274.1	29.7	310.0	6288.3	16.2	0.022
1-2	370.0	4454.4	150.0	1809.9	59.5	120.0	1447.9	67.6	60.0	724.0	83.8	40.0	482.6	89.2	0.013
2-1	370.0	5754.1	370.0	5754.1	0.0	370.0	5754.1	0.0	350.0	5443.1	5.4	100.0	1555.2	73.0	0.017
2-2	370.0	7192.7	370.0	7192.7	0.0	370.0	7192.7	0.0	350.0	6803.9	5.4	70.0	1360.8	81.1	0.021
3-1	370.0	6239.4	370.0	6239.4	0.0	370.0	6239.4	0.0	370.0	6239.4	0.0	290.0	4890.4	21.6	0.018
3-2	370.0	6473.4	370.0	6473.4	0.0	370.0	6473.4	0.0	370.0	6473.4	0.0	330.0	5773.6	10.8	0.019
4-1	370.0	6905.0	370.0	6905.0	0.0	370.0	6905.0	0.0	350.0	6531.7	5.4	320.0	5971.9	13.5	0.020
4-2	370.0	6639.4	370.0	6639.4	0.0	370.0	6639.4	0.0	350.0	6280.5	5.4	230.0	4127.2	37.8	0.019
5-1	370.0	7192.7	370.0	7192.7	0.0	370.0	7192.7	0.0	360.0	6998.3	2.7	300.0	5831.9	18.9	0.021
5-2	370.0	7398.2	370.0	7398.2	0.0	370.0	7398.2	0.0	360.0	7198.2	2.7	270.0	5398.7	27.0	0.021
6-1	370.0	6639.4	370.0	6639.4	0.0	370.0	6639.4	0.0	370.0	6639.4	0.0	350.0	6280.5	5.4	0.019
6-2	370.0	7398.2	370.0	7398.2	0.0	370.0	7398.2	0.0	370.0	7398.2	0.0	300.0	5998.5	18.9	0.021
7-1	370.0	9247.7	370.0	9247.7	0.0	370.0	9247.7	0.0	370.0	9247.7	0.0	200.0	4998.8	45.9	0.027
7-2	370.0	8352.8	370.0	8352.8	0.0	370.0	8352.8	0.0	370.0	8352.8	0.0	160.0	3612.0	56.8	0.024
8-1	370.0	6639.4	370.0	6639.4	0.0	370.0	6639.4	0.0	370.0	6639.4	0.0	360.0	6459.9	2.7	0.019
8-2	370.0	6473.4	370.0	6473.4	0.0	370.0	6473.4	0.0	370.0	6473.4	0.0	320.0	5598.6	13.5	0.019
9-1	370.0	5952.6	370.0	5952.6	0.0	370.0	5952.6	0.0	360.0	5791.7	2.7	210.0	3378.5	43.2	0.017
9-2	370.0	6315.5	370.0	6315.5	0.0	370.0	6315.5	0.0	370.0	6315.5	0.0	270.0	4608.6	27.0	0.018
10-1	370.0	7094.1	370.0	7094.1	0.0	370.0	7094.1	0.0	370.0	7094.1	0.0	370.0	7094.1	0.0	0.021
10-2	370.0	6393.5	370.0	6393.5	0.0	370.0	6393.5	0.0	370.0	6393.5	0.0	350.0	6047.9	5.4	0.019
11-1	370.0	6021.8	370.0	6021.8	0.0	370.0	6021.8	0.0	370.0	6021.8	0.0	240.0	3906.0	35.1	0.017
11-2	370.0	5952.6	370.0	5952.6	0.0	370.0	5952.6	0.0	370.0	5952.6	0.0	370.0	5952.6	0.0	0.017
12-1	370.0	9771.2	370.0	9771.2	0.0	370.0	9771.2	0.0	370.0	9771.2	0.0	370.0	9771.2	0.0	0.028
12-2	370.0	7294.0	370.0	7294.0	0.0	370.0	7294.0	0.0	370.0	7294.0	0.0	370.0	7294.0	0.0	0.021
13-1	370.0	5818.8	370.0	5818.8	0.0	370.0	5818.8	0.0	370.0	5818.8	0.0	360.0	5661.5	2.7	0.017
13-2	370.0	7967.3	370.0	7967.3	0.0	370.0	7967.3	0.0	370.0	7967.3	0.0	370.0	7967.3	0.0	0.023
14-1	370.0	6315.5	370.0	6315.5	0.0	370.0	6315.5	0.0	370.0	6315.5	0.0	270.0	4606.6	27.0	0.018
14-2	370.0	8091.8	370.0	8091.8	0.0	370.0	8091.8	0.0	370.0	8091.8	0.0	310.0	6779.6	16.2	0.023

SEP10611

TREAT	INPUT GR/ 100 CF	INPUT MG/ DAY	REMOVAL AT 6 IN. GR/ 100 CF	REMOVAL AT 6 IN. MG/ DAY	REMOVAL AT 6 IN. PER CENT	REMOVAL AT 12 IN. GR/ 100 CF	REMOVAL AT 12 IN. MG/ DAY	REMOVAL AT 12 IN. PER CENT	REMOVAL AT 18 IN. GR/ 100 CF	REMOVAL AT 18 IN. MG/ DAY	REMOVAL AT 18 IN. PER CENT	REMOVAL AT 24 IN. GR/ 100 CF	REMOVAL AT 24 IN. MG/ DAY	REMOVAL AT 24 IN. PER CENT	FLOW (CFM)
1-1	380.0	7998.1	350.0	6998.3	7.9	170.0	3399.2	55.3	300.0	5998.5	21.1	300.0	5998.5	21.1	0.021
1-2	380.0	3421.4	80.0	722.4	78.9	80.0	722.4	78.9	40.0	361.2	89.5	20.0	180.6	94.7	0.010
2-1	380.0	8058.6	380.0	8058.6	0.0	340.0	7210.3	10.5	320.0	6786.2	15.8	200.0	4241.4	47.4	0.023
2-2	380.0	8058.6	330.0	6998.3	13.2	330.0	6998.3	13.2	360.0	7634.5	5.3	180.0	3817.2	52.6	0.023
3-1	380.0	8442.4	380.0	8442.4	0.0	380.0	8442.4	0.0	360.0	7998.0	5.3	300.0	6665.0	21.1	0.024
3-2	380.0	7708.3	230.0	4665.5	39.5	250.0	5071.2	34.2	170.0	3448.4	55.3	210.0	4259.8	44.7	0.022
4-1	380.0	8182.6	380.0	8182.6	0.0	380.0	8182.6	0.0	370.0	7967.3	2.6	320.0	6890.6	15.8	0.023
4-2	380.0	8058.6	380.0	8058.6	0.0	310.0	6574.1	18.4	310.0	6574.1	18.4	190.0	4029.3	50.0	0.023
5-1	380.0	8719.2	380.0	8719.2	0.0	380.0	8719.2	0.0	380.0	8719.2	0.0	250.0	5736.3	34.2	0.025
5-2	380.0	6818.8	380.0	6818.8	0.0	380.0	6818.8	0.0	380.0	6818.8	0.0	310.0	5562.7	18.4	0.019
6-1	380.0	6998.3	380.0	6998.3	0.0	380.0	6998.3	0.0	360.0	6629.9	5.3	330.0	6077.5	13.2	0.020
6-2	380.0	8864.5	380.0	8864.5	0.0	380.0	8864.5	0.0	380.0	8864.5	0.0	370.0	8631.2	2.6	0.025
7-1	380.0	8058.6	380.0	8058.6	0.0	380.0	8058.6	0.0	380.0	8058.6	0.0	270.0	5725.9	28.9	0.023
7-2	380.0	8864.5	380.0	8864.5	0.0	380.0	8864.5	0.0	380.0	8864.5	0.0	190.0	4432.2	50.0	0.025
8-1	380.0	5909.7	380.0	5909.7	0.0	380.0	5909.7	0.0	380.0	5909.7	0.0	360.0	5598.6	5.3	0.017
8-2	380.0	7091.6	380.0	7091.6	0.0	380.0	7091.6	0.0	380.0	7091.6	0.0	380.0	7091.6	0.0	0.020
9-1	380.0	7285.9	380.0	7285.9	0.0	380.0	7285.9	0.0	380.0	7285.9	0.0	380.0	7285.9	0.0	0.021
9-2	390.0	7798.1	390.0	7798.1	0.0	390.0	7798.1	0.0	390.0	7798.1	0.0	230.0	4598.9	41.0	0.021
10-1	390.0	7278.2	390.0	7278.2	0.0	390.0	7278.2	0.0	380.0	7091.6	2.6	380.0	7091.6	2.6	0.020
10-2	390.0	7089.2	380.0	6907.4	2.6	390.0	7089.2	0.0	380.0	6907.4	2.6	340.0	6180.3	12.8	0.019
11-1	390.0	7089.2	390.0	7089.2	0.0	390.0	7089.2	0.0	390.0	7089.2	0.0	360.0	6543.8	7.7	0.019
11-2	390.0	7376.6	390.0	7376.6	0.0	390.0	7376.6	0.0	380.0	7187.4	2.6	210.0	3972.0	46.2	0.020
12-1	390.0	7278.2	390.0	7278.2	0.0	390.0	7278.2	0.0	380.0	7091.6	2.6	240.0	4478.9	38.5	0.020
12-2	390.0	7477.6	390.0	7477.6	0.0	390.0	7477.6	0.0	390.0	7477.6	0.0	330.0	6327.2	15.4	0.021
13-1	390.0	7688.3	390.0	7688.3	0.0	390.0	7688.3	0.0	390.0	7688.3	0.0	200.0	3942.7	48.7	0.021
13-2	390.0	8147.3	390.0	8147.3	0.0	390.0	8147.3	0.0	380.0	7938.3	2.6	330.0	6893.8	15.4	0.022
14-1	390.0	7798.1	390.0	7798.1	0.0	390.0	7798.1	0.0	390.0	7798.1	0.0	360.0	7198.2	7.7	0.021
14-2	390.0	8529.2	390.0	8529.2	0.0	390.0	8529.2	0.0	390.0	8529.2	0.0	220.0	4811.3	43.6	0.023

SEPT 14

TREAT	INPUT GR/ 100 CF	INPUT MG/ DAY	REMOVAL AT 6 IN. GR/ 100 CF	REMOVAL AT 6 IN. MG/ DAY	REMOVAL AT 6 IN. PER CENT	REMOVAL AT 12 IN. GR/ 100 CF	REMOVAL AT 12 IN. MG/ DAY	REMOVAL AT 12 IN. PER CENT	REMOVAL AT 18 IN. GR/ 100 CF	REMOVAL AT 18 IN. MG/ DAY	REMOVAL AT 18 IN. PER CENT	REMOVAL AT 24 IN. GR/ 100 CF	REMOVAL AT 24 IN. MG/ DAY	REMOVAL AT 24 IN. PER CENT	FLOW (CFM)
1-1	420.0	8397.9	260.0	5198.7	38.1	220.0	4398.9	47.6	360.0	7198.2	14.3	370.0	7398.2	11.9	0.021
1-2	420.0	3792.6	130.0	1173.9	69.0	110.0	993.3	73.8	40.0	361.2	90.5	20.0	180.6	95.2	0.010
2-1	420.0	7634.5	420.0	7634.5	0.0	420.0	7634.5	0.0	420.0	7634.5	0.0	160.0	2908.4	61.9	0.019
2-2	420.0	8519.6	420.0	8519.6	0.0	420.0	8519.6	0.0	390.0	7911.1	7.1	220.0	4462.7	47.6	0.022
3-1	420.0	9185.2	420.0	9185.2	0.0	420.0	9185.2	0.0	420.0	9185.2	0.0	380.0	8310.5	9.5	0.023
3-2	420.0	7838.1	420.0	7838.1	0.0	420.0	7838.1	0.0	400.0	7464.8	4.8	370.0	6905.0	11.9	0.020
4-1	420.0	9331.0	420.0	9331.0	0.0	420.0	9331.0	0.0	420.0	9331.0	0.0	370.0	8220.2	11.9	0.024
4-2	420.0	8774.0	420.0	8774.0	0.0	420.0	8774.0	0.0	420.0	8774.0	0.0	330.0	6893.8	21.4	0.022
5-1	420.0	9963.7	420.0	9963.7	0.0	420.0	9963.7	0.0	390.0	9252.0	7.1	280.0	6642.4	33.3	0.025
5-2	420.0	8644.9	420.0	8644.9	0.0	420.0	8644.9	0.0	420.0	8644.9	0.0	380.0	7821.6	9.5	0.022
6-1	420.0	8164.7	420.0	8164.7	0.0	420.0	8164.7	0.0	400.0	7775.9	4.8	370.0	7192.7	11.9	0.021
6-2	420.0	10313.3	420.0	10313.3	0.0	420.0	10313.3	0.0	400.0	9822.1	4.8	380.0	9331.0	9.5	0.026
7-1	420.0	6321.0	420.0	6321.0	0.0	420.0	6321.0	0.0	410.0	6170.5	2.4	240.0	3612.0	42.9	0.016
7-2	420.0	9797.6	420.0	9797.6	0.0	420.0	9797.6	0.0	420.0	9797.6	0.0	260.0	6065.2	38.1	0.025
8-1	420.0	9797.6	370.0	8631.2	11.9	390.0	9097.8	7.1	350.0	8164.7	16.7	400.0	9331.0	4.8	0.025
8-2	420.0	8052.8	420.0	8052.8	0.0	420.0	8052.8	0.0	420.0	8052.8	0.0	410.0	7861.1	2.4	0.021
9-1	420.0	9481.5	420.0	9481.5	0.0	420.0	9481.5	0.0	420.0	9481.5	0.0	320.0	7224.0	23.8	0.024
9-2	420.0	9637.0	420.0	9637.0	0.0	420.0	9637.0	0.0	420.0	9637.0	0.0	210.0	4818.5	50.0	0.025
10-1	420.0	7536.6	420.0	7536.6	0.0	420.0	7536.6	0.0	420.0	7536.6	0.0	300.0	5383.3	28.6	0.019
10-2	420.0	9481.5	420.0	9481.5	0.0	420.0	9481.5	0.0	420.0	9481.5	0.0	380.0	8578.5	9.5	0.024
11-1	420.0	8774.0	420.0	8774.0	0.0	420.0	8774.0	0.0	420.0	8774.0	0.0	400.0	8356.2	4.8	0.022
11-2	420.0	9637.0	420.0	9637.0	0.0	420.0	9637.0	0.0	420.0	9637.0	0.0	420.0	9637.0	0.0	0.025
12-1	420.0	9637.0	420.0	9637.0	0.0	420.0	9637.0	0.0	420.0	9637.0	0.0	390.0	8948.6	7.1	0.025
12-2	420.0	9185.2	420.0	9185.2	0.0	420.0	9185.2	0.0	420.0	9185.2	0.0	350.0	7654.4	16.7	0.023
13-1	420.0	9043.9	420.0	9043.9	0.0	420.0	9043.9	0.0	420.0	9043.9	0.0	420.0	9043.9	0.0	0.023
13-2	420.0	9481.5	420.0	9481.5	0.0	420.0	9481.5	0.0	420.0	9481.5	0.0	360.0	8127.0	14.3	0.024
14-1	420.0	9185.2	420.0	9185.2	0.0	420.0	9185.2	0.0	420.0	9185.2	0.0	280.0	6123.5	33.3	0.023
14-2	420.0	10135.4	420.0	10135.4	0.0	420.0	10135.4	0.0	420.0	10135.4	0.0	370.0	8928.8	11.9	0.026

SEPT 17

TREAT	INPUT GR/ 100 CF	INPUT MG/ DAY	REMOVAL AT 6 IN. GR/ 100 CF	REMOVAL AT 6 IN. MG/ DAY	REMOVAL AT 6 IN. PER CENT	REMOVAL AT 12 IN. GR/ 100 CF	REMOVAL AT 12 IN. MG/ DAY	REMOVAL AT 12 IN. PER CENT	REMOVAL AT 18 IN. GR/ 100 CF	REMOVAL AT 18 IN. MG/ DAY	REMOVAL AT 18 IN. PER CENT	REMOVAL AT 24 IN. GR/ 100 CF	REMOVAL AT 24 IN. MG/ DAY	REMOVAL AT 24 IN. PER CENT	FLOW (CFM)
1-1	440.0	5548.2	230.0	2900.2	47.7	270.0	3404.6	38.6	410.0	5169.9	6.8	330.0	4161.1	25.0	0.014
1-2	440.0	3079.2	170.0	1189.7	61.4	100.0	699.8	77.3	40.0	279.9	90.9	10.0	70.0	97.7	0.007
2-1	440.0	5498.6	390.0	4873.8	11.4	370.0	4623.9	15.9	400.0	4998.8	9.1	90.0	1124.7	79.5	0.013
2-2	440.0	6037.7	370.0	5077.2	15.9	380.0	5214.4	13.6	400.0	5488.8	9.1	100.0	1372.2	77.3	0.015
3-1	440.0	5309.0	440.0	5309.0	0.0	440.0	5309.0	0.0	430.0	5188.4	2.3	310.0	3740.5	29.5	0.013
3-2	440.0	5263.7	440.0	5263.7	0.0	440.0	5263.7	0.0	430.0	5144.0	2.3	370.0	4426.3	15.9	0.013
4-1	440.0	5309.0	440.0	5309.0	0.0	440.0	5309.0	0.0	440.0	5309.0	0.0	220.0	2654.5	50.0	0.013
4-2	440.0	5498.6	440.0	5498.6	0.0	440.0	5498.6	0.0	440.0	5498.6	0.0	310.0	3874.0	29.5	0.013
5-1	440.0	5219.1	440.0	5219.1	0.0	430.0	5100.4	2.3	420.0	4981.8	4.5	220.0	2609.5	50.0	0.013
5-2	440.0	5047.9	440.0	5047.9	0.0	440.0	5047.9	0.0	430.0	4933.2	2.3	260.0	2982.9	40.9	0.012
6-1	440.0	5865.2	440.0	5865.2	0.0	440.0	5865.2	0.0	430.0	5731.9	2.3	300.0	3999.0	31.8	0.014
6-2	440.0	3421.4	440.0	3421.4	0.0	440.0	3421.4	0.0	400.0	3110.3	9.1	340.0	2643.8	22.7	0.008
7-1	440.0	5132.1	440.0	5132.1	0.0	440.0	5132.1	0.0	440.0	5132.1	0.0	170.0	1982.8	61.4	0.012
7-2	440.0	5132.1	440.0	5132.1	0.0	440.0	5132.1	0.0	440.0	5132.1	0.0	110.0	1283.0	75.0	0.012
8-1	440.0	5702.3	440.0	5702.3	0.0	390.0	5054.3	11.4	360.0	4665.5	18.2	380.0	4924.7	13.6	0.014
8-2	440.0	4737.3	440.0	4737.3	0.0	420.0	4522.0	4.5	440.0	4737.3	0.0	400.0	4306.6	9.1	0.012
9-1	440.0	5132.1	440.0	5132.1	0.0	440.0	5132.1	0.0	440.0	5132.1	0.0	260.0	3032.6	40.9	0.012
9-2	440.0	5047.9	440.0	5047.9	0.0	440.0	5047.9	0.0	360.0	4130.1	18.2	180.0	2065.1	59.1	0.012
10-1	440.0	5450.0	440.0	5450.0	0.0	440.0	5450.0	0.0	440.0	5450.0	0.0	240.0	2972.7	45.5	0.013
10-2	440.0	5309.0	440.0	5309.0	0.0	440.0	5309.0	0.0	440.0	5309.0	0.0	250.0	3016.5	43.2	0.013
11-1	440.0	4887.7	440.0	4887.7	0.0	440.0	4887.7	0.0	440.0	4887.7	0.0	420.0	4565.5	4.5	0.012
11-2	440.0	5006.9	440.0	5006.9	0.0	440.0	5006.9	0.0	440.0	5006.9	0.0	290.0	3300.0	34.1	0.012
12-1	440.0	5089.7	440.0	5089.7	0.0	440.0	5089.7	0.0	440.0	5089.7	0.0	120.0	1388.1	72.7	0.012
12-2	440.0	4849.2	440.0	4849.2	0.0	440.0	4849.2	0.0	440.0	4849.2	0.0	130.0	1432.7	70.5	0.012
13-1	440.0	5219.1	440.0	5219.1	0.0	440.0	5219.1	0.0	440.0	5219.1	0.0	280.0	3321.2	36.4	0.013
13-2	440.0	4887.7	440.0	4887.7	0.0	440.0	4887.7	0.0	440.0	4887.7	0.0	160.0	1777.3	63.6	0.012
14-1	440.0	4811.3	440.0	4811.3	0.0	440.0	4811.3	0.0	440.0	4811.3	0.0	160.0	1749.6	63.6	0.012
14-2	440.0	5132.1	440.0	5132.1	0.0	440.0	5132.1	0.0	430.0	5015.4	2.3	140.0	1632.9	68.2	0.012

SEPT2465

TREAT	INPUT GR/ 100 CF	INPUT MG/ DAY	REMOVAL AT 6 IN. GR/ 100 CF	REMOVAL AT 6 IN. MG/ DAY	REMOVAL AT 6 IN. PER CENT	REMOVAL AT 12 IN. GR/ 100 CF	REMOVAL AT 12 IN. MG/ DAY	REMOVAL AT 12 IN. PER CENT	REMOVAL AT 18 IN. GR/ 100 CF	REMOVAL AT 18 IN. MG/ DAY	REMOVAL AT 18 IN. PER CENT	REMOVAL AT 24 IN. GR/ 100 CF	REMOVAL AT 24 IN. MG/ DAY	REMOVAL AT 24 IN. PER CENT	FLOW (CFM)
1-1	440.0	4396.9	200.0	1999.5	54.5	200.0	1999.5	54.5	390.0	3899.0	11.4	370.0	3699.1	15.9	0.011
1-2	440.0	2463.4	100.0	559.9	77.3	30.0	168.0	93.2	20.0	112.0	95.5	10.0	56.0	97.7	0.006
2-1	440.0	4595.9	170.0	1775.7	61.4	280.0	2924.7	36.4	340.0	3551.4	22.7	50.0	522.3	88.6	0.011
2-2	440.0	5263.7	280.0	3349.6	36.4	280.0	3349.6	36.4	350.0	4187.0	20.5	70.0	837.4	84.1	0.013
3-1	440.0	4561.8	440.0	4561.8	0.0	440.0	4561.8	0.0	440.0	4561.8	0.0	290.0	3006.7	34.1	0.011
3-2	440.0	4737.3	440.0	4737.3	0.0	440.0	4737.3	0.0	440.0	4737.3	0.0	320.0	3445.3	27.3	0.012
4-1	440.0	4595.9	440.0	4595.9	0.0	440.0	4595.9	0.0	430.0	4491.4	2.3	330.0	3446.9	25.0	0.011
4-2	440.0	4495.2	440.0	4495.2	0.0	440.0	4495.2	0.0	440.0	4495.2	0.0	440.0	4495.2	0.0	0.011
5-1	440.0	4595.9	440.0	4595.9	0.0	440.0	4595.9	0.0	440.0	4595.9	0.0	170.0	1775.7	61.4	0.011
5-2	440.0	2799.3	440.0	2799.3	0.0	440.0	2799.3	0.0	440.0	2799.3	0.0	110.0	699.8	75.0	0.007
6-1	440.0	3732.4	440.0	3732.4	0.0	370.0	3138.6	15.9	220.0	1866.2	50.0	20.0	169.7	95.5	0.009
6-2	440.0	4306.6	440.0	4306.6	0.0	370.0	3621.5	15.9	290.0	2838.5	34.1	60.0	587.3	86.4	0.010
7-1	440.0	7419.9	440.0	7419.9	0.0	440.0	7419.9	0.0	420.0	7082.6	4.5	290.0	4890.4	34.1	0.018
7-2	440.0	1986.6	440.0	1986.6	0.0	440.0	1986.6	0.0	360.0	1625.4	18.2	30.0	135.5	93.2	0.005
8-1	440.0	5132.1	440.0	5132.1	0.0	440.0	5132.1	0.0	440.0	5132.1	0.0	310.0	3615.8	29.5	0.012
8-2	440.0	4276.7	440.0	4276.7	0.0	440.0	4276.7	0.0	440.0	4276.7	0.0	380.0	3693.5	13.6	0.010
9-1	440.0	4926.8	440.0	4926.8	0.0	440.0	4926.8	0.0	440.0	4926.8	0.0	220.0	2463.4	50.0	0.012
9-2	440.0	4462.7	440.0	4462.7	0.0	440.0	4462.7	0.0	320.0	3245.6	27.3	160.0	1622.8	63.6	0.011
10-1	440.0	4811.3	440.0	4811.3	0.0	390.0	4264.6	11.4	310.0	3389.8	29.5	140.0	1530.9	68.2	0.012
10-2	440.0	4926.8	410.0	4590.9	6.8	360.0	4031.0	18.2	300.0	3359.2	31.8	120.0	1343.7	72.7	0.012
11-1	440.0	4398.9	440.0	4398.9	0.0	440.0	4398.9	0.0	430.0	4298.9	2.3	300.0	2999.3	31.8	0.011
11-2	440.0	4665.5	440.0	4665.5	0.0	440.0	4665.5	0.0	440.0	4665.5	0.0	280.0	2969.0	36.4	0.011
12-1	440.0	4926.8	420.0	4702.8	4.5	360.0	4031.0	18.2	170.0	1903.5	61.4	10.0	112.0	97.7	0.012
12-2	440.0	4966.5	420.0	4740.8	4.5	370.0	4176.4	15.9	210.0	2370.4	52.3	10.0	112.9	97.7	0.012
13-1	440.0	5089.7	440.0	5089.7	0.0	440.0	5089.7	0.0	430.0	4974.0	2.3	160.0	1850.8	63.6	0.012
13-2	440.0	4926.8	440.0	4926.8	0.0	440.0	4926.8	0.0	440.0	4926.8	0.0	280.0	3135.2	36.4	0.012
14-1	440.0	4887.7	400.0	4443.4	9.1	370.0	4110.1	15.9	260.0	2888.2	40.9	40.0	444.3	90.9	0.012
14-2	440.0	5355.2	410.0	4990.1	6.8	380.0	4624.9	13.6	330.0	4016.4	25.0	20.0	243.4	95.5	0.013

OCT 162

TREAT	INPUT GR/ 100 CF	INPUT MG/ DAY	REMOVAL AT 6 IN. GR/ 100 CF	REMOVAL AT 6 IN. MG/ DAY	REMOVAL AT 6 IN. PER CENT	REMOVAL AT 12 IN. GR/ 100 CF	REMOVAL AT 12 IN. MG/ DAY	REMOVAL AT 12 IN. PER CENT	REMOVAL AT 18 IN. GR/ 100 CF	REMOVAL AT 18 IN. MG/ DAY	REMOVAL AT 18 IN. PER CENT	REMOVAL AT 24 IN. GR/ 100 CF	REMOVAL AT 24 IN. MG/ DAY	REMOVAL AT 24 IN. PER CENT	FLOW (CFM)
1-1	430.0	4425.4	430.0	4425.4	0.0	280.0	2881.6	34.9	430.0	4425.4	0.0	390.0	4013.7	9.3	0.011
1-2	430.0	2755.7	220.0	1399.7	48.8	260.0	1654.1	39.5	140.0	890.7	67.4	40.0	254.5	90.7	0.007
2-1	430.0	3682.9	210.0	1896.3	51.2	320.0	2889.6	25.6	270.0	2438.1	37.2	20.0	180.6	95.3	0.010
2-2	430.0	5015.4	410.0	4782.2	4.7	400.0	4665.5	7.0	300.0	3499.1	30.2	10.0	116.6	97.7	0.012
3-1	430.0	4012.3	430.0	4012.3	0.0	430.0	4012.3	0.0	430.0	4012.3	0.0	420.0	3919.0	2.3	0.010
3-2	430.0	3761.6	430.0	3761.6	0.0	430.0	3761.6	0.0	430.0	3761.6	0.0	420.0	3674.1	2.3	0.009
4-1	430.0	4458.2	430.0	4458.2	0.0	420.0	4354.5	2.3	280.0	2903.0	34.9	200.0	2073.6	53.5	0.011
4-2	430.0	3253.3	350.0	2648.0	18.6	310.0	2345.4	27.9	240.0	1815.8	44.2	140.0	1059.2	67.4	0.008
5-1	430.0	3882.9	430.0	3882.9	0.0	390.0	3521.7	9.3	340.0	3070.2	20.9	170.0	1535.1	60.5	0.010
5-2	430.0	6687.2	430.0	6687.2	0.0	430.0	6687.2	0.0	390.0	6065.2	9.3	360.0	5598.6	16.3	0.017
6-1	430.0	3343.6	430.0	3343.6	0.0	430.0	3343.6	0.0	420.0	3265.9	2.3	280.0	2177.2	34.9	0.008
6-2	430.0	2006.2	430.0	2006.2	0.0	430.0	2006.2	0.0	430.0	2006.2	0.0	100.0	466.6	76.7	0.005
7-1	430.0	5233.5	430.0	5233.5	0.0	430.0	5233.5	0.0	430.0	5233.5	0.0	230.0	2799.3	46.5	0.013
7-2	430.0	4012.3	430.0	4012.3	0.0	430.0	4012.3	0.0	420.0	3919.0	2.3	90.0	839.8	79.1	0.010
8-1	430.0	5233.5	430.0	5233.5	0.0	430.0	5233.5	0.0	430.0	5233.5	0.0	300.0	3651.3	30.2	0.013
8-2	430.0	4012.3	430.0	4012.3	0.0	430.0	4012.3	0.0	410.0	3825.7	4.7	140.0	1306.3	67.4	0.010
9-1	430.0	4150.7	430.0	4150.7	0.0	400.0	3861.1	7.0	350.0	3378.5	18.6	100.0	965.3	76.7	0.010
9-2	430.0	4298.9	430.0	4298.9	0.0	410.0	4099.0	4.7	210.0	2099.5	51.2	110.0	1099.7	74.4	0.011
10-1	430.0	3882.9	400.0	3612.0	7.0	360.0	3250.8	16.3	350.0	3160.5	18.6	70.0	632.1	83.7	0.010
10-2	430.0	3933.7	100.0	914.8	76.7	30.0	274.4	93.0	20.0	183.0	95.3	20.0	183.0	95.3	0.010
11-1	430.0	3343.6	310.0	2410.5	27.9	320.0	2488.3	25.6	240.0	1866.2	44.2	80.0	622.1	81.4	0.008
11-2	430.0	4150.7	160.0	1544.4	62.8	170.0	1641.0	60.5	150.0	1447.9	65.1	150.0	1447.9	65.1	0.010
12-1	430.0	3343.6	250.0	1944.0	41.9	250.0	1944.0	41.9	270.0	2099.5	37.2	10.0	77.8	97.7	0.008
12-2	430.0	4094.2	300.0	2856.4	30.2	310.0	2951.7	27.9	150.0	1428.2	65.1	10.0	95.2	97.7	0.010
13-1	430.0	4012.3	430.0	4012.3	0.0	430.0	4012.3	0.0	410.0	3825.7	4.7	110.0	1026.4	74.4	0.010
13-2	430.0	3882.9	430.0	3882.9	0.0	430.0	3882.9	0.0	430.0	3882.9	0.0	140.0	1264.2	67.4	0.010
14-1	430.0	3761.6	430.0	3761.6	0.0	410.0	3586.6	4.7	250.0	2187.0	41.9	10.0	87.5	97.7	0.009
14-2	430.0	4629.6	400.0	4306.6	7.0	350.0	3768.3	18.6	300.0	3230.0	30.2	30.0	323.0	93.0	0.012

OCT 4

TREAT	INPUT GR/ 100 CF	INPUT MG/ DAY	REMOVAL AT 6 IN. GR/ 100 CF	REMOVAL AT 6 IN. MG/ DAY	REMOVAL AT 6 IN. PER CENT	REMOVAL AT 12 IN. GR/ 100 CF	REMOVAL AT 12 IN. MG/ DAY	REMOVAL AT 12 IN. PER CENT	REMOVAL AT 18 IN. GR/ 100 CF	REMOVAL AT 18 IN. MG/ DAY	REMOVAL AT 18 IN. PER CENT	REMOVAL AT 24 IN. GR/ 100 CF	REMOVAL AT 24 IN. MG/ DAY	REMOVAL AT 24 IN. PER CENT	FLOW (CFM)
1-1	400.0	4665.5	400.0	4665.5	0.0	400.0	4665.5	0.0	380.0	4432.2	5.0	280.0	3265.9	30.0	0.012
1-2	400.0	2332.8	190.0	1108.1	52.5	90.0	524.9	77.5	10.0	58.3	97.5	20.0	116.6	95.0	0.006
2-1	400.0	4306.6	300.0	3230.0	25.0	340.0	3660.8	15.0	330.0	3553.0	17.5	80.0	861.3	80.0	0.012
2-2	400.0	5232.4	350.0	4578.3	12.5	350.0	4578.3	12.5	360.0	4709.1	10.0	110.0	1438.9	72.5	0.014
3-1	400.0	4589.0	400.0	4589.0	0.0	400.0	4589.0	0.0	400.0	4589.0	0.0	280.0	3212.3	30.0	0.012
3-2	400.0	4408.4	400.0	4408.4	0.0	400.0	4408.4	0.0	360.0	3967.5	10.0	240.0	2645.0	40.0	0.012
4-1	400.0	4589.0	380.0	4359.6	5.0	340.0	3900.7	15.0	320.0	3671.2	20.0	150.0	1720.9	62.5	0.012
4-2	400.0	3999.0	400.0	3999.0	0.0	400.0	3999.0	0.0	380.0	3799.1	5.0	150.0	1499.6	62.5	0.011
5-1	400.0	4665.5	340.0	3965.7	15.0	340.0	3965.7	15.0	270.0	3149.2	32.5	50.0	583.2	87.5	0.012
5-2	400.0	4478.9	400.0	4478.9	0.0	380.0	4255.0	5.0	380.0	4255.0	5.0	60.0	671.8	85.0	0.012
6-1	400.0	3732.4	400.0	3732.4	0.0	400.0	3732.4	0.0	400.0	3732.4	0.0	140.0	1306.3	65.0	0.010
6-2	400.0	6435.2	400.0	6435.2	0.0	400.0	6435.2	0.0	400.0	6435.2	0.0	360.0	5791.7	10.0	0.017
7-1	400.0	2666.0	400.0	2666.0	0.0	400.0	2666.0	0.0	400.0	2666.0	0.0	90.0	599.9	77.5	0.007
7-2	400.0	5089.7	400.0	5089.7	0.0	400.0	5089.7	0.0	340.0	4326.2	15.0	110.0	1399.7	72.5	0.014
8-1	400.0	4954.5	400.0	4954.5	0.0	400.0	4954.5	0.0	400.0	4954.5	0.0	350.0	4335.2	12.5	0.013
8-2	400.0	4147.1	400.0	4147.1	0.0	400.0	4147.1	0.0	400.0	4147.1	0.0	200.0	2073.6	50.0	0.011
9-1	400.0	4665.5	400.0	4665.5	0.0	400.0	4665.5	0.0	360.0	4199.0	10.0	180.0	2099.5	55.0	0.012
9-2	400.0	4665.5	400.0	4665.5	0.0	380.0	4432.2	5.0	310.0	3615.8	22.5	170.0	1982.8	57.5	0.012
10-1	400.0	4478.9	400.0	4478.9	0.0	400.0	4478.9	0.0	390.0	4366.9	2.5	220.0	2463.4	45.0	0.012
10-2	400.0	4478.9	400.0	4478.9	0.0	400.0	4478.9	0.0	340.0	3807.1	15.0	150.0	1679.6	62.5	0.012
11-1	400.0	3942.7	400.0	3942.7	0.0	400.0	3942.7	0.0	400.0	3942.7	0.0	160.0	1577.1	60.0	0.011
11-2	400.0	4589.0	400.0	4589.0	0.0	400.0	4589.0	0.0	400.0	4589.0	0.0	310.0	3556.5	22.5	0.012
12-1	400.0	4147.1	380.0	3939.8	5.0	260.0	2695.6	35.0	300.0	3110.3	25.0	50.0	518.4	87.5	0.011
12-2	400.0	4478.9	400.0	4478.9	0.0	400.0	4478.9	0.0	380.0	4255.0	5.0	80.0	895.8	80.0	0.012
13-1	400.0	4665.5	400.0	4665.5	0.0	380.0	4432.2	5.0	340.0	3965.7	15.0	190.0	2216.1	52.5	0.012
13-2	400.0	4209.5	400.0	4209.5	0.0	400.0	4209.5	0.0	380.0	3999.0	5.0	174.0	1831.1	56.5	0.011
14-1	400.0	4306.6	400.0	4306.6	0.0	400.0	4306.6	0.0	400.0	4306.6	0.0	90.0	969.0	77.5	0.012
14-2	400.0	4704.7	400.0	4704.7	0.0	400.0	4704.7	0.0	390.0	4587.1	2.5	110.0	1293.8	72.5	0.013

OCT 8

TREAT	INPUT GR/ 100 CF	INPUT MG/ DAY	REMOVAL AT 6 IN. GR/ 100 CF	REMOVAL AT 6 IN. MG/ DAY	REMOVAL AT 6 IN. PER CENT	REMOVAL AT 12 IN. GR/ 100 CF	REMOVAL AT 12 IN. MG/ DAY	REMOVAL AT 12 IN. PER CENT	REMOVAL AT 18 IN. GR/ 100 CF	REMOVAL AT 18 IN. MG/ DAY	REMOVAL AT 18 IN. PER CENT	REMOVAL AT 24 IN. GR/ 100 CF	REMOVAL AT 24 IN. MG/ DAY	REMOVAL AT 24 IN. PER CENT	FLOW (CFM)
1-1	440.0	4528.3	440.0	4528.3	0.0	440.0	4528.3	0.0	430.0	4425.4	2.3	410.0	4219.6	6.8	0.011
1-2	440.0	2368.6	110.0	592.2	75.0	30.0	161.5	93.2	10.0	53.8	97.7	10.0	53.8	97.7	0.006
2-1	440.0	3849.1	440.0	3849.1	0.0	440.0	3849.1	0.0	430.0	3761.6	2.3	140.0	1224.7	68.2	0.009
2-2	440.0	4430.6	440.0	4430.6	0.0	440.0	4430.6	0.0	420.0	4229.2	4.5	200.0	2013.9	54.5	0.011
3-1	440.0	4247.2	440.0	4247.2	0.0	440.0	4247.2	0.0	440.0	4247.2	0.0	370.0	3571.5	15.9	0.010
3-2	440.0	3421.4	440.0	3421.4	0.0	440.0	3421.4	0.0	440.0	3421.4	0.0	350.0	2721.6	20.5	0.008
4-1	440.0	4561.8	440.0	4561.8	0.0	440.0	4561.8	0.0	430.0	4458.2	2.3	380.0	3939.8	13.6	0.011
4-2	440.0	3801.5	440.0	3801.5	0.0	440.0	3801.5	0.0	430.0	3715.1	2.3	340.0	2937.6	22.7	0.009
5-1	440.0	3079.2	440.0	3079.2	0.0	440.0	3079.2	0.0	430.0	3009.3	2.3	360.0	2519.4	18.2	0.007
5-2	440.0	4306.6	440.0	4306.6	0.0	440.0	4306.6	0.0	440.0	4306.6	0.0	270.0	2642.7	38.6	0.010
6-1	440.0	3421.4	440.0	3421.4	0.0	440.0	3421.4	0.0	440.0	3421.4	0.0	170.0	1321.9	61.4	0.008
6-2	440.0	4398.9	440.0	4398.9	0.0	440.0	4398.9	0.0	430.0	4298.9	2.3	230.0	2299.4	47.7	0.011
7-1	440.0	2566.0	440.0	2566.0	0.0	440.0	2566.0	0.0	440.0	2566.0	0.0	140.0	816.5	68.2	0.006
7-2	440.0	5263.7	440.0	5263.7	0.0	440.0	5263.7	0.0	440.0	5263.7	0.0	200.0	2392.6	54.5	0.013
8-1	440.0	4161.1	440.0	4161.1	0.0	440.0	4161.1	0.0	440.0	4161.1	0.0	420.0	3972.0	4.5	0.010
8-2	440.0	3999.0	440.0	3999.0	0.0	440.0	3999.0	0.0	440.0	3999.0	0.0	440.0	3999.0	0.0	0.010
9-1	380.0	3826.4	380.0	3826.4	0.0	380.0	3826.4	0.0	370.0	3725.7	2.6	300.0	3020.8	21.1	0.011
9-2	380.0	3772.1	380.0	3772.1	0.0	370.0	3672.9	2.6	300.0	2978.0	21.1	170.0	1687.5	55.3	0.011
10-1	380.0	3223.5	380.0	3223.5	0.0	380.0	3223.5	0.0	380.0	3223.5	0.0	290.0	2460.0	23.7	0.009
10-2	380.0	2799.3	380.0	2799.3	0.0	380.0	2799.3	0.0	380.0	2799.3	0.0	230.0	1694.3	39.5	0.008
11-1	380.0	1969.9	380.0	1969.9	0.0	380.0	1969.9	0.0	380.0	1969.9	0.0	330.0	1710.7	13.2	0.006
11-2	380.0	3693.5	380.0	3693.5	0.0	380.0	3693.5	0.0	380.0	3693.5	0.0	210.0	2041.2	44.7	0.010
12-1	380.0	2727.5	340.0	2440.4	10.5	300.0	2153.3	21.1	180.0	1292.0	52.6	50.0	358.9	86.8	0.008
12-2	380.0	3545.8	380.0	3545.8	0.0	380.0	3545.8	0.0	360.0	3359.2	5.3	120.0	1119.7	68.4	0.010
13-1	380.0	3499.1	380.0	3499.1	0.0	380.0	3499.1	0.0	370.0	3407.1	2.6	90.0	828.7	76.3	0.010
13-2	380.0	3092.3	380.0	3092.3	0.0	380.0	3092.3	0.0	370.0	3010.9	2.6	130.0	1057.9	65.8	0.009
14-1	380.0	3223.5	380.0	3223.5	0.0	380.0	3223.5	0.0	380.0	3223.5	0.0	120.0	1017.9	68.4	0.009
14-2	380.0	3910.8	380.0	3910.8	0.0	360.0	3705.0	5.3	320.0	3293.3	15.8	170.0	1749.6	55.3	0.011

OCT 18

TREAT	INPUT GR/ 100 CF	INPUT MG/ DAY	REMOVAL AT 6 IN. GR/ 100 CF	REMOVAL AT 6 IN. MG/ DAY	REMOVAL AT 6 IN. PER CENT	REMOVAL AT 12 IN. GR/ 100 CF	REMOVAL AT 12 IN. MG/ DAY	REMOVAL AT 12 IN. PER CENT	REMOVAL AT 18 IN. GR/ 100 CF	REMOVAL AT 18 IN. MG/ DAY	REMOVAL AT 18 IN. PER CENT	REMOVAL AT 24 IN. GR/ 100 CF	REMOVAL AT 24 IN. MG/ DAY	REMOVAL AT 24 IN. PER CENT	FLOW (CFM)
1-1	360.0	3967.5	160.0	1763.3	55.6	190.0	2094.0	47.2	280.0	3085.9	22.2	250.0	2755.2	30.6	0.012
1-2	360.0	2879.5	310.0	2479.4	13.9	200.0	1599.6	44.4	30.0	239.9	91.7	10.0	80.0	97.2	0.009
2-1	360.0	3906.0	160.0	1736.0	55.6	10.0	108.5	97.2	10.0	108.5	97.2	10.0	108.5	97.2	0.012
2-2	360.0	4130.1	80.0	917.8	77.8	10.0	114.7	97.2	10.0	114.7	97.2	10.0	114.7	97.2	0.012
3-1	360.0	4063.5	350.0	3950.6	2.8	360.0	4063.5	0.0	360.0	4063.5	0.0	220.0	2483.3	38.9	0.012
3-2	360.0	3936.5	360.0	3936.5	0.0	360.0	3936.5	0.0	330.0	3608.5	8.3	210.0	2296.3	41.7	0.012
4-1	360.0	4130.1	360.0	4130.1	0.0	360.0	4130.1	0.0	350.0	4015.4	2.8	270.0	3097.6	25.0	0.012
4-2	360.0	4130.1	360.0	4130.1	0.0	360.0	4130.1	0.0	340.0	3900.7	5.6	180.0	2065.1	50.0	0.012
5-1	360.0	4164.3	360.0	4164.3	0.0	330.0	3817.2	8.3	310.0	3585.9	13.9	90.0	1041.1	75.0	0.012
5-2	360.0	3967.5	360.0	3967.5	0.0	350.0	3857.3	2.8	320.0	3526.7	11.1	150.0	1653.1	58.3	0.012
6-1	360.0	3651.3	310.0	3144.2	13.9	310.0	3144.2	13.9	290.0	2941.3	19.4	150.0	1521.4	58.3	0.011
6-2	360.0	3677.9	320.0	3269.3	11.1	320.0	3269.3	11.1	290.0	2962.8	19.4	120.0	1226.0	66.7	0.011
7-1	360.0	4798.8	360.0	4798.8	0.0	360.0	4798.8	0.0	360.0	4798.8	0.0	180.0	2399.4	50.0	0.014
7-2	360.0	4709.1	360.0	4709.1	0.0	360.0	4709.1	0.0	350.0	4578.3	2.8	160.0	2092.9	55.6	0.014
8-1	360.0	4940.0	360.0	4940.0	0.0	360.0	4940.0	0.0	350.0	4802.7	2.8	300.0	4116.6	16.7	0.015
8-2	360.0	4164.3	360.0	4164.3	0.0	360.0	4164.3	0.0	360.0	4164.3	0.0	190.0	2197.8	47.2	0.012
9-1	360.0	4164.3	360.0	4164.3	0.0	360.0	4164.3	0.0	320.0	3701.6	11.1	170.0	1966.5	52.8	0.012
9-2	360.0	4270.1	360.0	4270.1	0.0	360.0	4270.1	0.0	180.0	2135.1	50.0	100.0	1186.1	72.2	0.013
10-1	360.0	3999.0	360.0	3999.0	0.0	330.0	3665.8	8.3	300.0	3332.5	16.7	130.0	1444.1	63.9	0.012
10-2	360.0	3788.5	360.0	3788.5	0.0	340.0	3578.1	5.6	260.0	2736.2	27.8	20.0	210.5	94.4	0.011
11-1	360.0	2099.5	360.0	2099.5	0.0	360.0	2099.5	0.0	340.0	1982.8	5.6	120.0	699.8	66.7	0.006
11-2	360.0	4063.5	360.0	4063.5	0.0	360.0	4063.5	0.0	360.0	4063.5	0.0	270.0	3047.6	25.0	0.012
12-1	360.0	3427.7	360.0	3427.7	0.0	350.0	3332.5	2.8	110.0	1047.4	69.4	10.0	95.2	97.2	0.010
12-2	360.0	3999.0	360.0	3999.0	0.0	360.0	3999.0	0.0	210.0	2332.8	41.7	10.0	111.1	97.2	0.012
13-1	360.0	3999.0	360.0	3999.0	0.0	360.0	3999.0	0.0	360.0	3999.0	0.0	290.0	3221.4	19.4	0.012
13-2	360.0	3677.9	360.0	3677.9	0.0	360.0	3677.9	0.0	360.0	3677.9	0.0	160.0	1634.6	55.6	0.011
14-1	360.0	3788.5	360.0	3788.5	0.0	360.0	3788.5	0.0	310.0	3262.4	13.9	140.0	1473.3	61.1	0.011
14-2	360.0	4199.0	360.0	4199.0	0.0	360.0	4199.0	0.0	350.0	4082.3	2.8	150.0	1749.6	58.3	0.012

OCT 21

TREAT	INPUT GR/ 100 CF	INPUT MG/ DAY	REMOVAL AT 6 IN. GR/ 100 CF	REMOVAL AT 6 IN. MG/ DAY	REMOVAL AT 6 IN. PER CENT	REMOVAL AT 12 IN. GR/ 100 CF	REMOVAL AT 12 IN. MG/ DAY	REMOVAL AT 12 IN. PER CENT	REMOVAL AT 18 IN. GR/ 100 CF	REMOVAL AT 18 IN. MG/ DAY	REMOVAL AT 18 IN. PER CENT	REMOVAL AT 24 IN. GR/ 100 CF	REMOVAL AT 24 IN. MG/ DAY	REMOVAL AT 24 IN. PER CENT	FLOW (CFM)
1-1	370.0	3407.1	370.0	3407.1	0.0	370.0	3407.1	0.0	370.0	3407.1	0.0	350.0	3222.9	5.4	0.010
1-2	370.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-1	370.0	2976.3	370.0	2976.3	0.0	370.0	2976.3	0.0	360.0	2895.8	2.7	120.0	965.3	67.6	0.009
2-2	370.0	3407.1	370.0	3407.1	0.0	370.0	3407.1	0.0	360.0	3315.0	2.7	90.0	828.7	75.7	0.010
3-1	370.0	3236.7	370.0	3236.7	0.0	370.0	3236.7	0.0	360.0	3149.2	2.7	220.0	1924.5	40.5	0.009
3-2	370.0	3236.7	370.0	3236.7	0.0	370.0	3236.7	0.0	370.0	3236.7	0.0	280.0	2449.4	24.3	0.009
4-1	370.0	3298.6	370.0	3298.6	0.0	370.0	3298.6	0.0	360.0	3209.4	2.7	240.0	2139.6	35.1	0.010
4-2	370.0	3216.6	370.0	3216.6	0.0	370.0	3216.6	0.0	350.0	3042.7	5.4	290.0	2521.1	21.6	0.009
5-1	370.0	3236.7	370.0	3236.7	0.0	370.0	3236.7	0.0	340.0	2974.3	8.1	240.0	2099.5	35.1	0.009
5-2	370.0	2877.1	370.0	2877.1	0.0	370.0	2877.1	0.0	310.0	2410.5	16.2	230.0	1788.4	37.8	0.008
6-1	370.0	2959.3	370.0	2959.3	0.0	370.0	2959.3	0.0	370.0	2959.3	0.0	310.0	2479.4	16.2	0.009
6-2	370.0	2725.6	370.0	2725.6	0.0	370.0	2725.6	0.0	370.0	2725.6	0.0	250.0	1841.7	32.4	0.008
7-1	370.0	1523.2	370.0	1523.2	0.0	370.0	1523.2	0.0	300.0	1235.0	18.9	10.0	41.2	97.3	0.004
7-2	370.0	1644.0	370.0	1644.0	0.0	370.0	1644.0	0.0	370.0	1644.0	0.0	10.0	44.4	97.3	0.005
8-1	370.0	3499.1	370.0	3499.1	0.0	370.0	3499.1	0.0	360.0	3404.6	2.7	280.0	2648.0	24.3	0.010
8-2	370.0	3429.6	370.0	3429.6	0.0	370.0	3429.6	0.0	330.0	3058.9	10.8	170.0	1575.8	54.1	0.010
9-1	370.0	3452.5	370.0	3452.5	0.0	370.0	3452.5	0.0	200.0	1866.2	45.9	160.0	1493.0	56.8	0.010
9-2	370.0	3522.9	370.0	3522.9	0.0	350.0	3332.5	5.4	200.0	1904.3	45.9	200.0	1904.3	45.9	0.010
10-1	370.0	3362.8	370.0	3362.8	0.0	370.0	3362.8	0.0	370.0	3362.8	0.0	200.0	1817.7	45.9	0.010
10-2	370.0	3780.1	140.0	1430.3	62.2	50.0	510.8	86.5	20.0	204.3	94.6	10.0	102.2	97.3	0.011
11-1	370.0	1233.0	250.0	833.1	32.4	210.0	699.8	43.2	140.0	466.6	62.2	10.0	33.3	97.3	0.004
11-2	370.0	3341.1	370.0	3341.1	0.0	370.0	3341.1	0.0	370.0	3341.1	0.0	250.0	2257.5	32.4	0.010
12-1	370.0	3452.5	360.0	3359.2	2.7	280.0	2612.7	24.3	290.0	2706.0	21.6	140.0	1306.3	62.2	0.010
12-2	370.0	3277.7	370.0	3277.7	0.0	370.0	3277.7	0.0	290.0	2569.0	21.6	200.0	1771.7	45.9	0.009
13-1	370.0	3547.1	370.0	3547.1	0.0	370.0	3547.1	0.0	370.0	3547.1	0.0	190.0	1821.5	48.6	0.010
13-2	370.0	3752.7	370.0	3752.7	0.0	370.0	3752.7	0.0	370.0	3752.7	0.0	220.0	2231.3	40.5	0.011
14-1	370.0	3752.7	370.0	3752.7	0.0	370.0	3752.7	0.0	350.0	3549.9	5.4	160.0	1622.8	56.8	0.011
14-2	370.0	3699.1	370.0	3699.1	0.0	370.0	3699.1	0.0	370.0	3699.1	0.0	130.0	1299.7	64.9	0.011

OCT 28

TREAT	INPUT GR/ 100 CF	INPUT MG/ DAY	REMOVAL AT 6 IN. GR/ 100 CF	REMOVAL AT 6 IN. MG/ DAY	REMOVAL AT 6 IN. PER CENT	REMOVAL AT 12 IN. GR/ 100 CF	REMOVAL AT 12 IN. MG/ DAY	REMOVAL AT 12 IN. PER CENT	REMOVAL AT 18 IN. GR/ 100 CF	REMOVAL AT 18 IN. MG/ DAY	REMOVAL AT 18 IN. PER CENT	REMOVAL AT 24 IN. GR/ 100 CF	REMOVAL AT 24 IN. MG/ DAY	REMOVAL AT 24 IN. PER CENT	FLOW (CFM)
1-1	380.0	3954.1	150.0	1521.4	60.5	150.0	1521.4	60.5	310.0	3144.2	18.4	240.0	2434.2	36.8	0.011
1-2	380.0	1948.2	150.0	769.0	60.5	60.0	307.6	84.2	10.0	51.3	97.4	10.0	51.3	97.4	0.005
2-1	380.0	3499.1	120.0	1105.0	68.4	300.0	2762.5	21.1	320.0	2946.6	15.8	100.0	920.8	73.7	0.010
2-2	380.0	3799.1	290.0	2499.4	34.2	300.0	2999.3	21.1	140.0	1399.7	63.2	110.0	1099.7	71.1	0.011
3-1	380.0	4091.3	380.0	4091.3	0.0	380.0	4091.3	0.0	380.0	4091.3	0.0	210.0	2261.0	44.7	0.012
3-2	380.0	3668.1	380.0	3668.1	0.0	360.0	3475.0	5.3	150.0	1447.9	60.5	260.0	2509.7	31.6	0.010
4-1	380.0	3772.1	350.0	3474.3	7.9	220.0	2183.9	42.1	320.0	3176.5	15.8	210.0	2084.6	44.7	0.011
4-2	380.0	3693.5	290.0	2818.8	23.7	310.0	3013.1	18.4	270.0	2624.4	28.9	140.0	1360.8	63.2	0.010
5-1	380.0	8864.5	370.0	8631.2	2.6	350.0	8164.7	7.9	320.0	7464.8	15.8	320.0	7464.8	15.8	0.025
5-2	380.0	3693.5	380.0	3693.5	0.0	370.0	3596.3	2.6	330.0	3207.5	13.2	210.0	2041.2	44.7	0.010
6-1	380.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6-2	380.0	2954.8	340.0	2643.8	10.5	310.0	2410.5	18.4	240.0	1866.2	36.8	140.0	1088.6	63.2	0.008
7-1	380.0	6044.0	380.0	6044.0	0.0	350.0	5566.8	7.9	330.0	5248.7	13.2	90.0	1431.5	76.3	0.017
7-2	380.0	4432.2	380.0	4432.2	0.0	380.0	4432.2	0.0	360.0	4199.0	5.3	70.0	816.5	81.6	0.012
8-1	380.0	2954.8	380.0	2954.8	0.0	380.0	2954.8	0.0	360.0	2799.3	5.3	160.0	1244.1	57.9	0.008
8-2	380.0	4029.3	380.0	4029.3	0.0	380.0	4029.3	0.0	380.0	4029.3	0.0	170.0	1802.6	55.3	0.011
9-1	380.0	4155.2	380.0	4155.2	0.0	380.0	4155.2	0.0	350.0	3827.2	7.9	120.0	1312.2	68.4	0.012
9-2	380.0	4060.1	380.0	4060.1	0.0	370.0	3953.2	2.6	200.0	2136.9	47.4	110.0	1175.3	71.1	0.011
10-1	380.0	4255.0	380.0	4255.0	0.0	380.0	4255.0	0.0	360.0	4031.0	5.3	240.0	2687.3	36.8	0.012
10-2	380.0	4585.1	300.0	3619.8	21.1	310.0	3740.5	18.4	290.0	3499.1	23.7	120.0	1447.9	68.4	0.013
11-1	380.0	9670.4	380.0	9670.4	0.0	380.0	9670.4	0.0	380.0	9670.4	0.0	370.0	9415.9	2.6	0.027
11-2	380.0	4091.3	370.0	3983.6	2.6	330.0	3553.0	13.2	290.0	3122.3	23.7	160.0	1722.7	57.9	0.012
12-1	380.0	3939.8	380.0	3939.8	0.0	360.0	3732.4	5.3	340.0	3525.1	10.5	190.0	1969.9	50.0	0.011
12-2	380.0	3882.3	380.0	3882.3	0.0	360.0	3677.9	5.3	360.0	3677.9	5.3	160.0	1634.6	57.9	0.011
13-1	380.0	4432.2	380.0	4432.2	0.0	370.0	4315.6	2.6	350.0	4082.3	7.9	280.0	3265.9	26.3	0.012
13-2	380.0	4585.1	380.0	4585.1	0.0	380.0	4585.1	0.0	370.0	4464.4	2.6	90.0	1085.9	76.3	0.013
14-1	380.0	4432.2	380.0	4432.2	0.0	380.0	4432.2	0.0	360.0	4199.0	5.3	150.0	1749.6	60.5	0.012
14-2	380.0	4432.2	380.0	4432.2	0.0	380.0	4432.2	0.0	370.0	4315.6	2.6	180.0	2099.5	52.6	0.012

NOV 4

TREAT	INPUT GR/ 100 CF	INPUT MG/ DAY	REMOVAL AT 6 IN. GR/ 100 CF	REMOVAL AT 6 IN. MG/ DAY	REMOVAL AT 6 IN. PER CENT	REMOVAL AT 12 IN. GR/ 100 CF	REMOVAL AT 12 IN. MG/ DAY	REMOVAL AT 12 IN. PER CENT	REMOVAL AT 18 IN. GR/ 100 CF	REMOVAL AT 18 IN. MG/ DAY	REMOVAL AT 18 IN. PER CENT	REMOVAL AT 24 IN. GR/ 100 CF	REMOVAL AT 24 IN. MG/ DAY	REMOVAL AT 24 IN. PER CENT	FLOW (CFM)
1-1	340.0	3090.5	230.0	2063.6	32.4	260.0	2332.8	23.5	280.0	2512.2	17.6	160.0	1435.5	52.9	0.010
1-2	340.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-1	340.0	2984.1	10.0	84.8	97.1	20.0	169.7	94.1	10.0	84.8	97.1	10.0	84.8	97.1	0.009
2-2	340.0	3375.1	10.0	99.3	97.1	10.0	99.3	97.1	10.0	99.3	97.1	10.0	99.3	97.1	0.011
3-1	340.0	3282.0	340.0	3282.0	0.0	340.0	3282.0	0.0	330.0	3185.4	2.9	270.0	2606.3	20.6	0.010
3-2	340.0	3070.2	340.0	3070.2	0.0	340.0	3070.2	0.0	330.0	2979.9	2.9	190.0	1715.7	44.1	0.010
4-1	340.0	3448.4	250.0	2535.6	26.5	300.0	3042.7	11.8	300.0	3042.7	11.8	150.0	1521.4	55.9	0.011
4-2	340.0	3151.5	340.0	3151.5	0.0	300.0	2780.8	11.8	280.0	2595.4	17.6	90.0	834.2	73.5	0.010
5-1	340.0	3660.6	300.0	3230.0	11.8	280.0	3014.6	17.6	290.0	3122.3	14.7	200.0	2153.3	41.2	0.012
5-2	340.0	3130.8	340.0	3130.8	0.0	320.0	2946.6	5.9	290.0	2670.4	14.7	140.0	1289.2	58.8	0.010
6-1	340.0	5172.6	340.0	5172.6	0.0	330.0	5020.5	2.9	320.0	4868.4	5.9	250.0	3803.4	26.5	0.016
6-2	340.0	4326.2	340.0	4326.2	0.0	340.0	4326.2	0.0	320.0	4071.7	5.9	210.0	2672.1	38.2	0.014
7-1	340.0	3807.1	300.0	3359.2	11.8	200.0	2239.4	41.2	210.0	2351.4	38.2	60.0	671.8	82.4	0.012
7-2	340.0	3965.7	310.0	3615.8	8.8	320.0	3732.4	5.9	250.0	2916.0	26.5	40.0	466.6	88.2	0.012
8-1	340.0	4032.9	340.0	4032.9	0.0	340.0	4032.9	0.0	300.0	3558.4	11.8	190.0	2253.7	44.1	0.013
8-2	340.0	3578.1	340.0	3578.1	0.0	340.0	3578.1	0.0	320.0	3367.6	5.9	180.0	1894.3	47.1	0.011
9-1	340.0	3776.9	340.0	3776.9	0.0	320.0	3554.7	5.9	280.0	3110.3	17.6	120.0	1333.0	64.7	0.012
9-2	340.0	3660.6	340.0	3660.6	0.0	310.0	3337.6	8.8	130.0	1399.7	61.8	100.0	1076.7	70.6	0.012
10-1	340.0	3499.1	270.0	2776.7	20.6	230.0	2367.1	32.4	170.0	1749.6	50.0	80.0	823.3	76.5	0.011
10-2	340.0	3660.6	220.0	2368.6	35.3	230.0	2476.3	32.4	200.0	2153.3	41.2	60.0	645.0	82.4	0.012
11-1	340.0	4138.1	340.0	4138.1	0.0	330.0	4016.4	2.9	310.0	3773.0	8.8	180.0	2190.8	47.1	0.013
11-2	340.0	3525.1	340.0	3525.1	0.0	320.0	3317.7	5.9	300.0	3110.3	11.8	110.0	1140.5	67.6	0.011
12-1	340.0	3070.2	240.0	2167.2	29.4	140.0	1264.2	58.8	10.0	90.3	97.1	10.0	90.3	97.1	0.010
12-2	340.0	3193.8	230.0	2160.5	32.4	180.0	1690.9	47.1	10.0	93.9	97.1	10.0	93.9	97.1	0.010
13-1	340.0	3237.3	340.0	3237.3	0.0	340.0	3237.3	0.0	300.0	2856.4	11.8	130.0	1237.8	61.8	0.010
13-2	340.0	3499.1	340.0	3499.1	0.0	330.0	3396.2	2.9	280.0	2881.6	17.6	110.0	1132.1	67.6	0.011
14-1	340.0	3473.6	150.0	1532.5	55.9	40.0	408.7	88.2	10.0	102.2	97.1	10.0	102.2	97.1	0.011
14-2	340.0	3525.1	110.0	1140.5	67.6	100.0	1036.8	70.6	70.0	725.7	79.4	10.0	103.7	97.1	0.011

APPENDIX III

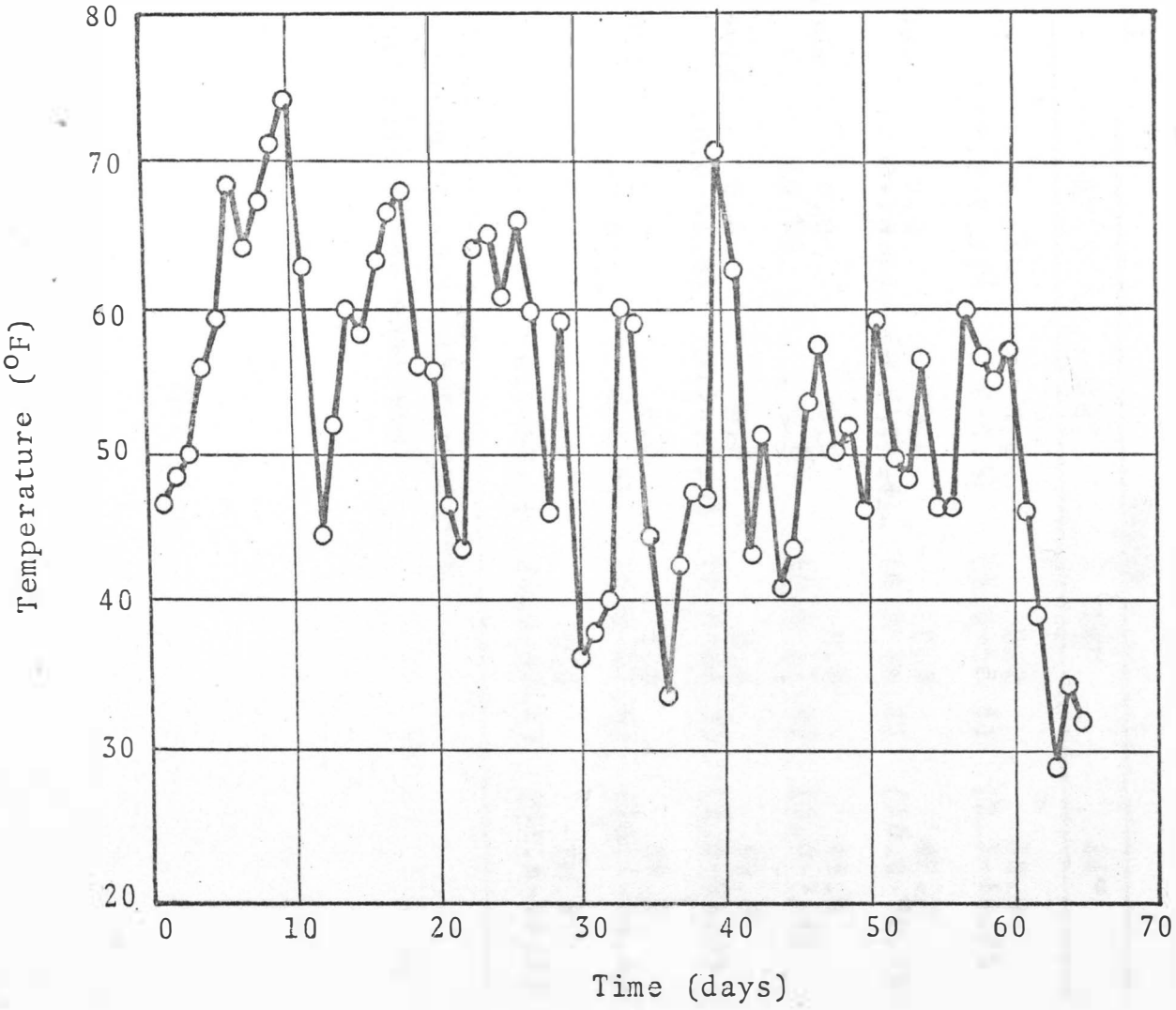
Analysis of Variance (49)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Treatments	13	175,681.2519	13,513.9424	61.90**
Time	13	110,436.8682	8,495.1437	38.91**
Depth	3	368,440.5395	122,813.5132	562.57**
Treatment x Time	169	185,474.6631	1,097.4832	5.03**
Treatment x Depth	39	51,645.9106	1,324.2541	6.07**
Time x Depth	39	44,073.5756	1,130.0917	5.18**
Treatment x Time x Depth	507	80,103.5337	157.9951	0.72 N.S.
Error	767	166,785.6856	218.3059	
Total	1547	1,182,642.0282		

**Indicates significance at the 0.01 level

APPENDIX IV

Daily Mean Temperatures at the Investigatio Site During the Period of Study (50)



APPENDIX V

Hydrogen Sulfide Removal Efficiencies According to Depth for Various Materials During the Last 33 Days of Study

Material	Depth			
	6"	12"	18"	24"
Corncobs	0.0[1] (0.0-2.8)[2]	0.0 (0.0-5.3)	0.0 (0.0-60.5)	30.8 (2.3-44.7)
Peat Moss	0.0 (0.0-13.9)	0.0 (0.0-18.4)	2.3 (0.0-36.8)	47.7 (10.0-76.7)
Styrofoam	0.0 (0.0)	0.0 (0.0)	0.0 (0.0-11.8)	45.6 (0.0-7.4)
Elm Leaves	0.0 (0.0-62.8)	0.0 (0.0-60.5)	2.8 (0.0-62.2)	52.5 (2.6-81.4)
Wood Chips	0.0 (0.0)	0.0 (0.0-5.0)	2.6 (0.0-17.6)	59.2 (19.4-74.4)
Scum Layer	0.0 (0.0-67.6)	0.0 (0.0-88.2)	5.4 (0.0-97.1)	70.4 (52.6-97.7)

[1]Median value of last seven analyses

[2]Range of last seven analyses